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Computer Revelation System Based Classification of Intact Cashew Grading System With Fuzzy Logic

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Abstract

Computer vision provides one alternative for an automated, non-destructive and cost-effective technique to accomplish these requirements. This inspection approach based on image analysis and processing has found a variety of different applications in the food industry.This paper proposed an intelligent fuzzy logic based computer vision system for classification of whole cashew kernels by assigning the grades. Proposed approach is divided into various phases. Image acquisition phase captures images of the cashew kernel under investigation. Pre-processing phase smoothes acquired image to handle distortion. The cashew part (region of interest) is differentiated from the background part of the image in segmentation phase. In this system color along with other morphological features such as length, width and thickness are considered as essential features, and extracted in the feature extraction phase. Obtained quantitative information is fuzzified and taken as input to the fuzzy inference system (FIS) during the fuzzy classification phase. Final grade of the cashew kernel is decided based on the result of the classification.

Keyword: Cashew kernel, Computer revelation system, Fuzzy inference system, Grade, Quality.

Introduction

The increased awareness and sophistication of con-sumers have created the expectation for improved quality in consumer food products. This in turn has increased the need for enhanced quality monitoring. Quality itself is defined as the sum of all those attributes which can lead to the production of products acceptable to the consumer when they are combined. Quality has been the subject of a large number of studies (Shewfelt & Bruckner, 2000). The basis of quality assessment is often subjective with attributes such as appearance, smell, texture, and flavor, frequently examined by human inspectors. Consequently

Francis (1980) found that human perception could be easily fooled. Together with the high labor costs, inconsistency and variability as-associated with human inspection accentuates the need for objective measurements systems. Recently automatic inspection systems, mainly based on camera—computer technology have been investigated for the sensory analysis of agricultural and food products. This system known as computer vision has proven to be successful for objective measurement of various agricultural.

Computer vision includes the capturing, processing and analysing images, facilitating the objective and non-destructive assessment of visual quality characteristics in food products (Timmermans, 1998). The potential of computer vision in the food industry has long been recognized (Tillett, 1990) and the food industry is now ranked among the top 10 industries using this techno-logy (Gunasekaran, 1996). Recent advances in hardware and software have aided in this expansion by providing low cost powerful solutions, leading to more studies on the development of computer vision systems in the food industry (Locht, Thomsen, & Mikkelsen, 1997; Sun, 2000). As a result automated visual inspection is undergoing substantial growth in the food industry because of its cost electiveness, consistency, superior speed and accuracy. Traditional visual quality inspection per-formed by human inspectors has the potential to be replaced by computer vision systems for many tasks. There is increasing evidence that machine vision is being adopted at commercial level (Locht et al., 1997). This paper presents the latest developments and recent advances of computer vision in the food industry. The fundamental elements of the systems and technologies involved are also examined.

Computer vision is the construction of explicit and meaningful descriptions of physical objects from images (Ballard & Brown, 1982). The term which is synonymous with machine vision embodies several processes. Images are acquired with a physical image sensor and dedicated computing hardware and software are used to analyze the images with the objective of performing a predefined visual task. Machine vision is also recognized as the integrated use of devices for non-contact optical sensing and computing and decision processes to receive and interpret an image of a real scene automatically. The technology aims to duplicate the effect of human vision by electronically perceiving and understanding an image (Sonka, Hlavac, & Boyle, 1999). Table 1 illustrates the benefits and drawbacks associated with this technology.

Hardware

Computer vision system generally consists of five basic components: illumination, a camera, an image Frame grabber

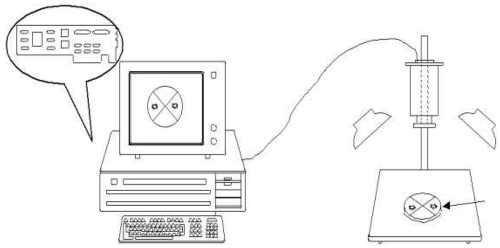


Fig. 1. Components of a computer vision system (Wang & Sun, 2002a).

capture board (frame grabber or digitizer), computer hardware and software as shown in Fig. 1.As with the human eye, vision systems are affected by the level and quality of illumination. Sarkar (1991) found that by adjustment of the lighting, the appearance of an object can be radically changed with the feature of interest clarified or blurred. Therefore the performance of the illumination system can greatly influence the quality of image and plays an important role in the overall efficiency and accuracy of the system (Novini, 1995).

In agreement Gunasekaran(1996) noted that a well-designed illumination system can help to improve the success of the image analysis by enhancing image contrast. Good lighting can reduce reflection, shadow and some noise giving decreased processing time. Various aspects of illumination including location, lamp type and color quality, need to be considered when de-signing an illumination system for applications in the food industry (Bachelor, 1985). Gunasekaran (2001) found that most lighting arrangements can be grouped as either front or back lighting. Front lighting (electron projection lithography or reflective illumination) is used in situations where surface feature extraction is required such as defect detection in apples (Yang, 1994). In contrast back lighting (transmitted illumination) is employed for the production of a silhouette image for critical edge dimensioning or for sub-surface feature analysis as in the size inspection of chicken pieces (So-borski, 1995). Light sources also differ but may include incandescent, fluorescent, lasers, X-ray tubes and infrared lamps. The choice of lamp affects quality and image analysis performance (Bachelor, 1985). The elimination of natural light effects from the image collection process is considered of importance with most modern systems having built in compensatory circuitry.

Image processing and analysis

Image processing and image analysis are recognized as being the core of computer vision (Krutz, Gibson, Cassens, & Zhang, 2000). Image processing involves a series of image operations that enhance the qualityof an

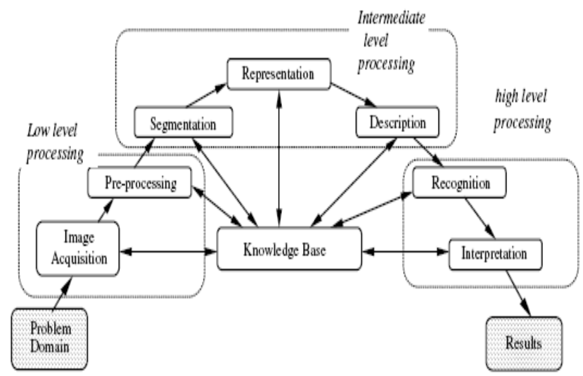


Fig. 2. Different levels in the image processing process (Sun, 2000).

image in order to remove defects such as geometric distortion, improper focus, repetitive noise, non-uni-form lighting and camera motion. Image analysis is the process of distinguishing the objects (regions of interest) from the background and producing quantitative in-formation, which is used in the subsequent control systems for decision making. Image processing/analysis involves a series of steps, which can be broadly divided into three levels: low level processing, intermediate level processing and high level processing (Gunasekaran & Ding, 1994; Sun, 2000), as indicated in Fig. 2 (Sun, 2000).

Low level processing includes image acquisition and pre-processing. Image acquisition is the transfer of the electronic signal from the sensing device into a numeric form. Image pre-processing refers to the initial processing of the raw image data for correction of geo-metric distortions, removal of noise, grey level correction and correction for blurring (Shirai, 1987). Pre-processing aims to improve image quality by sup-pressing undesired distortions or by the enhancement of important features of interest. Averaging and Gaussian filters are often used for noise reduction with their operation causing a smoothing in the image but having the effect of blurring edges. Also through the use of different filters fitted to CCD cameras images from particular spectral regions can be collected. Rigney, Brusewitz, and Kranzler (1992) used a 400–620 nm interference filter to examine contrast between defect and good asparagus tissue. A multi-spectral camera system with six band pass filters for the inspection of poultry carcasses was used to achieve better classification of abnormal car-cases.

Intermediate level processing involves image segmentation, and image representation and description. Image segmentation is one of the most important steps in the entire image processing technique, as subsequent extracted data are highly dependent on the accuracy of this operation. Its main aim is to divide an image into regions that have a strong correlation with objects or areas of interest.

Cashew is one of the most popular tree nuts. It is an expensive agricultural product and the prices depend on its quality.

Today, various kinds of cashews are available in the market with different qualities. To ascertain the quality, grade standard have been designed by considering the color and the size (weight) of the cashew kernel as important characteristic as shown in Table 1 and Table 2.

Several attempts have been made to mechanize the grading of the kernels, with limited success. Power driven rotary sieves are one mechanical method, another being the use of two outwardly rotating rubber rollers aligned at a diverging angle. Because of direct contact, which can cause the damage to the cashew kernel, mechanical grading system is not appropriate for the cashew kernel grading.

With exception of few mechanical methods, grading of the cashew kernel is still labor intensive manual process. Cashew kernels are mostly graded manually by skilled labor, employed only for grading, but the quality decisions may vary among the graders and are inconsistent. This way of grading presents many quality problems and grading is the last opportunity for the quality control.

Computer vision system has proven successful for the objective, online measurement of several agricultural products [2]. Computer vision based cashew grading system is an alternative to the manual, mechanical and optical methods. This method offers automated, high speed, non-destructive and cost effective technique for classification.

Designing such system without taking the physical properties of cashew kernel into consideration may yield poor results. In [1], the physical properties of the raw cashew nut and cashew kernel have been evaluated. Length (L), Width (W) and Thickness (T) of the cashew kernel plays vital role in deciding the grade of the cashew kernel which are measured as shown in Figure. 1.

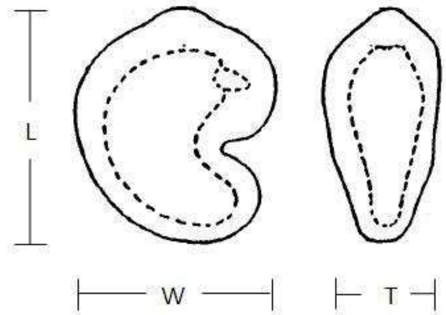


Figure 1: Length(L) ,Width(W) and Thickness (T) of the cashew kernel.

Cashew is one of the most popular and important commercial crop in India. India is second largest producer of raw cashew nut and the largest exporter of processed cashew nut. International markets for the cashew nut are still expanding, at the same time quality requirements and standards are increasingly applied to suppliers. To ascertain the quality, the grade standard has been designed by considering the color and the size of the cashew kernel as important characteristic as given in Table 1 and Table 2.

With exception of few mechanical methods, cashew kernels are mostly graded manually by skilled labor, employed only for grading, but the quality decisions may vary among the graders and are inconsistent. Grading systems based on mechanical instruments, optical devices and computer vision principles are in existence. The Mechanical grading system is not appropriate for grading because of direct contact which can cause the damage to the cashew kernel. On the other hand, optical grading devices utilize light with certain wavelength reflected from the object, to assess quality. This kind of optical devices cannot be used for the size or shape based grading.

Inspection and grading of the whole cashew kernels using computer vision provides an alternative to manual, mechanical and optical methods because it offers automated, high speed, non-destructive and cost-effective technique [3].

In [2], computer vision based classification of pistachio nut using neural network has been introduced, in which morphological features and fourier descriptor of the boundary has been considered as important feature to classify the pistachio nuts. Similarly, it is also possible to develop the automatic grading system for the whole cashew kernels using computer vision. In [1], the physical properties of the raw cashew nut and cashew kernel have been evaluated, which plays vital role in designing the cashew kernel grading system. Designing such equipment without taking the physical properties of cashew kernel into consideration may yield poor results. Neural network and the fuzzy logic have been successfully implemented for decision making in control system [3]. As the grading standard for cashew kernels are defined, fuzzy logic is appropriate because of the presence of the imprecision.

Methods and Material

The samples of whole cashews of different grades, used in this study were collected from Orbitta Exports, one of the cashew production companies of Gujarat. Initially the different samples of the each grade are taken and weight of each cashew kernel is measured individually with accuracy of 0.001 gm.

Cashew classification system consists of two digital cameras placed in front and top of cashew sample under investigation at distance of 15 cm from the sample position as well as perpendicular to each other, an image capturing box, fluorescent lamp and computer system. Image processing toolbox in the MATLAB is used as image analysis and image processing software. Fig. 1(a) shows the system architecture of the cashew classification system.

RGB Image Acquisition

Image acquisition involves capturing of RGB front and top view images of each cashew kernel under study. These RGB images are as shown in fig. 1(b) and 1(c).

Table 1. Color characteristic of whole cashew kernels

Cashew Kernel Type	Color Characteristic
White Whole (W)	Cashew kernels shall be white and free from damage.
Scorched Whole (SW)	Cashew kernels shall be light brown and free from damage.
Dessert Whole (DW)	Cashew kernels shall be dark brown, it may show deep black spot and free from damage.

Table 2. Weight characteristic of whole cashew kernels

White Whole Grades	Number of Kernels Per 454 gms.	Scorched Whole Grades	Number of Kernels Per 454 gms.	Dessert Whole Grades	Number of Kernels Per 454 gms.
W180	170-180	SW180	170-180	DW	No sepcification
W210	200-210	SW210	200-210		
W240	220-240	SW240	220-240		
W280	260-280	SW280	260-280		
W320	300-320	SW320	300-320		
W400	350-400	SW400	350-400		
W450	400-450	SW450	400-450		
W500	450-450	SW500	450-450		

Processing And segmentation

3x3 average filter is used to smooth the image during Preprocessing phase. Because of black background, obtained histogram is always bimodal as shown in fig. 2(b).

Threshold segmentation differentiates the cashew kernel region from background and converts the gray scale image into the binary image as shown in fig. 1(d) and 1(e).

Feature Extraction

To estimate the weight of the cashew kernel, quantitative information of the morphological features like Length (L), Width (W) and Thickness (T) are extracted by dividing the cashew kernel region into 'n' samples as shown in fig. 3. As the shape of cashew kernel is irregular, for better accuracy, averaging of these samples using equations (1), (2) and (3) is calculated.

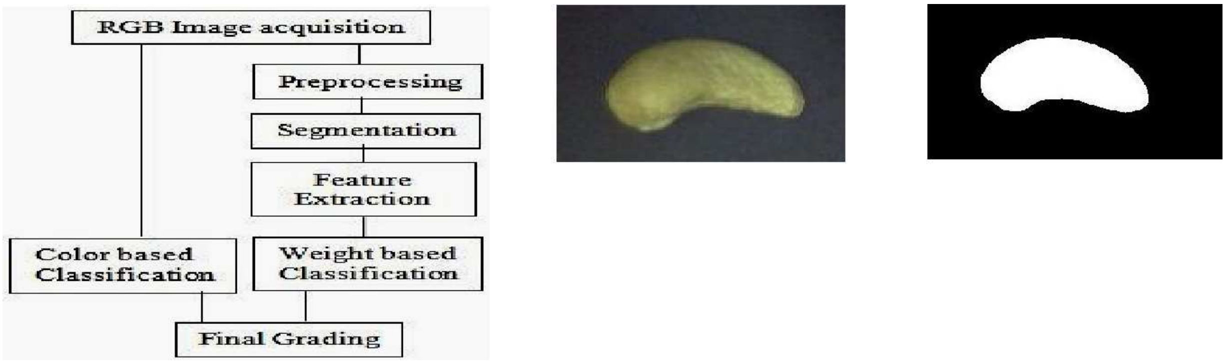


Fig. 1. (a) System Architecture (b) RGB top view (c) RGB front view (d) Binary top view (e) Binary front view of cashew kernel

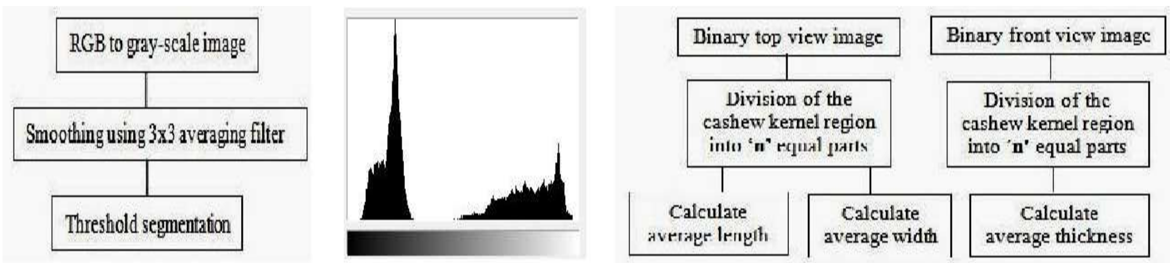


Fig. 2. (a) Preprocessing and Segmentation (b) Bi-modal Histogram of cashew kernel image (c) Morphological feature extraction

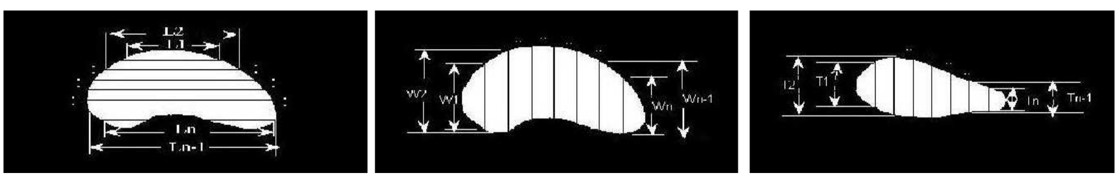


Fig. 3. Division of cashew kernel region into 'n' samples

$$\text{Length (L)} = \frac{L_1+L_2+ \dots +L_{n-1}+L_n}{n} \quad (1)$$

$$\text{Width (W)} = \frac{W_1+W_2+ \dots +W_{n-1}+W_n}{N} \quad (2)$$

$$\text{Thickness (T)} = \frac{T_1+T_2+ \dots +T_{n-1}+T_n}{N} \quad (3)$$

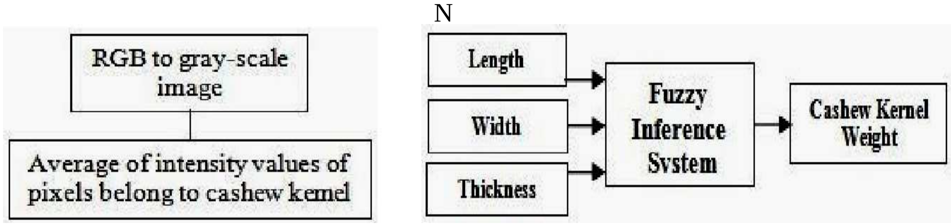
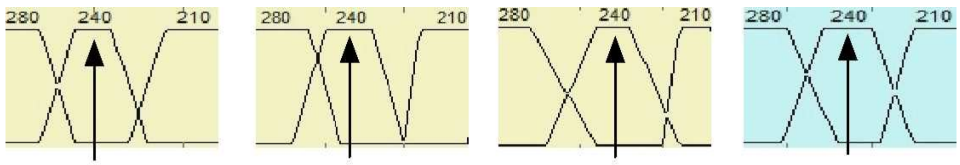


Fig. 4. (a) Color information extraction (b) Fuzzy inference system



If length=240 AND width=240 AND thickness=240 then Weight = 2

Classification

In order to classify the whole cashew kernel, in this method two level of classification has been employed. In the first level, cashew kernel is classified based on its color characteristic and in the second level it is classified on the basis of its weight.

Color based Classification.

At the first level of classification, cashew kernel is classified as whether it is white whole, scorched whole or dessert whole. Initially RGB image is converted to gray-scale image, then the average intensity of the pixels that belongs to the cashew region in the gray-scale image is determined and this intensity value is used for color based classification of the cashew kernel.

Weight based Classification.

In second level, Fuzzy Inference System (FIS) is designed to estimate the weight of the cashew kernel. Fuzzy inference is the process of formulating the mapping from given input to an output using fuzzy logic [4]. In the FIS, extracted value of the length, width, and thickness are interpreted as linguistic input variables and the cashew weight is considered as linguistic output variable.

Fuzzification.

The first step is to take the inputs and determine the degree to which they belong to each of the appropriate fuzzy sets via membership functions. Linguistic input variables 'length, width and thickness' and output variable 'weight' are fuzzified using trapezoid membership function because for more than one value of input, it is possible that membership function gives value 1, as shown in fig. 5.

Applying AND/OR operator.

There are eight fuzzy sets have been defined for each input variable, therefore at most 512 rules are possible with AND operator. The fuzzy operator AND is applied on three inputs to obtain the result of the antecedent for that rule. This resultant will be applied to the output function. This procedure is shown in fig. 5.

Rule aggregation.

Rule Aggregation is the process by which the fuzzy sets that represent the outputs of each rule are combined into a single fuzzy set

Defuzzification.

The final desired output for each variable is generally a single number. Therefore, the aggregation of fuzzy sets must be defuzzified in order to resolve a single output value that indicates the weight of the cashew kernel.

Final Grading

The grade of the cashew is decided based on the result of these two classifications. If at first level, cashew is classified as white based on the estimated color and at second level as 240 based on the weight, then the cashew is graded as W240.

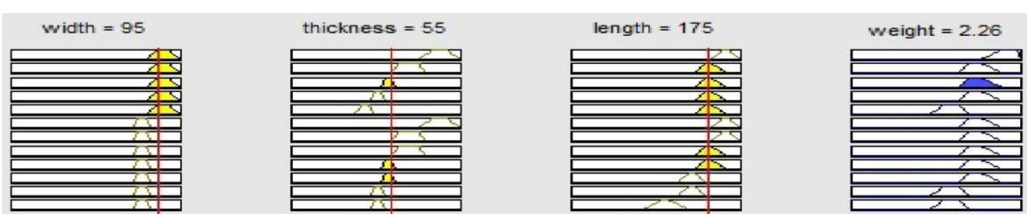


Fig. 6. Rule viewer

Conclusion

The results of this study show that colour features and a properly trained neural network can effectively classify cashew kernels. A computer vision–based system could be developed for automated grading and sorting More than 100 samples of each grade are collected which results into a total of more than 1700 samples and form the data set. The sample data set is partitioned into training set which consists of 66% of total samples and remaining 34% forms the testing set. Training set is used to trim down fuzzy rules from 512 to 61 and testing set is used to validate the final rules. Implementation of Fuzzy logic based computer vision system for classification of whole cashew kernel is an effective and efficient technique that provides automated, non-destructive, high speed solution with classifier accuracy of 89%.for cashew kernel grading.

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