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Classification of Intact Cashew Grading System with Fuzzy Logic

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Abstract

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.

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

Introduction

The increased awareness and sophistication of consumers 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 flavour, frequently examined by human inspectors.

Consequently Francis (1980) found that human perception could be easily fooled. Together with the high labour costs, inconsistency and variability 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.

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 recognised (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 effectiveness, 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 analyse the images with the objective of performing a predefined visual task. Machine vision is also recognised 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 e ect 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

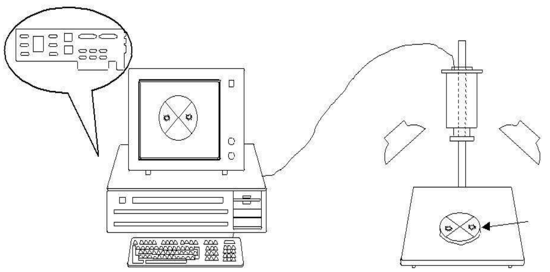


Figure 1. Components of a computer vision system (Wang & Sun, 2002a).

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 effeciency 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 colour 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 em-ployed 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 in-frared lamps. The choice of lamp affects quality and image analysis performance (Bachelor, 1985). The elimination of natural light effects from the image col-lection process is considered of importance with most modern systems having built in compensatory circuitry.

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. 2

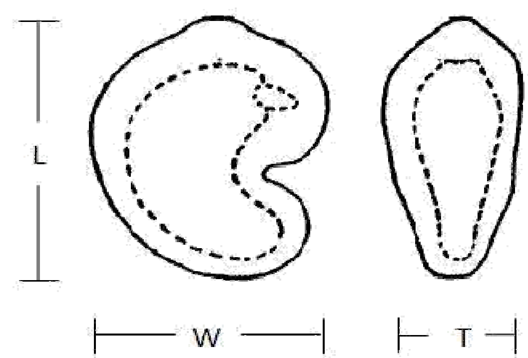


Figure 2 : Length (L), Width (W) and Thickness (T) of the cashew kernel.

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 o f G u j a r a t . Initially t h e different samples of the each grade are taken and weight of each cashew kernel is measured individually with accuracy of 0.001 gm.

A Computer Vision System is developed which 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 issue das image analysis and processing software to extract the features from the image. Fig. 3 shows the general operations for the cashew grading 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. 4(b) and 4(c). Threshold segmentation differentiates the cashew kernel region from background and converts the gray scale image into the binary image as shown in fig. 4(d) and 4(e).

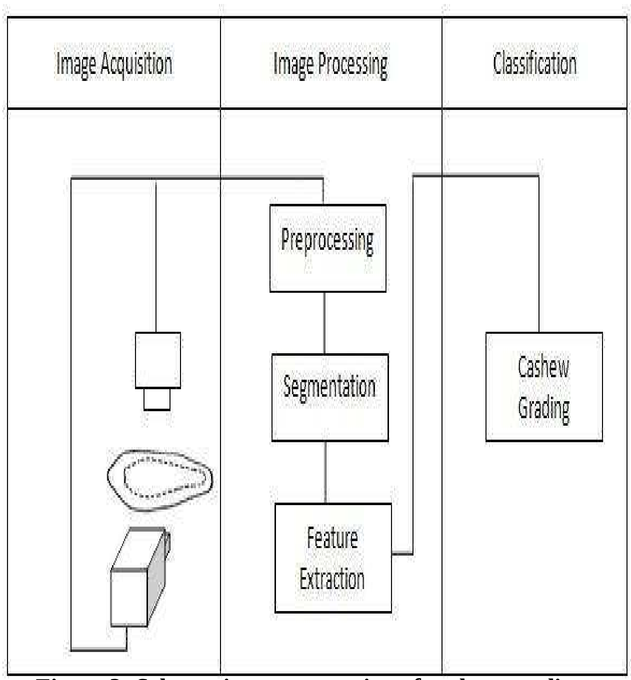


Figure 3: Schematic representation of cashew grading system

Preprocessing 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. 5(b).

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. 6. As the shape of cashew kernel is irregular, for better accuracy, averaging of these samples using equations (1), (2) and (3) is calculated.

Table 1. Color characteristic of the whole cashew kernel

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

Table 2. Weight characteristic of the whole cashew kernel

White Whole	Number of Kernels	Scorched Whole	Number of Kernels	Dessert Whole	Number of Kernels
W180	170-180	SW180	170-180	DW	No specification
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		

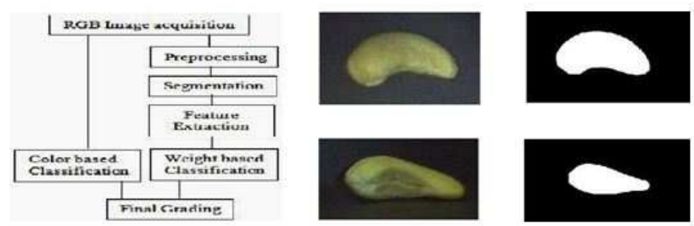


Figure 4. (a) System Architecture (b) RGB top view (c) RGB front view (d) Binary top view (e) Binary front view of cashew kernel

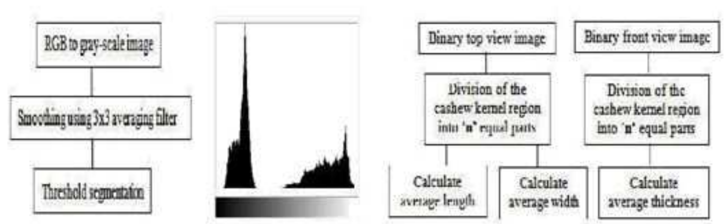


Figure 5. (a) Preprocessing and Segmentation (b) Bi-modal Histogram of cashew kernel image (c) Morphological feature extraction

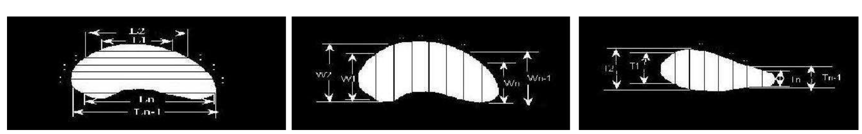


Figure 6. Division of cashew kernel region into 'n' samples

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

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

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

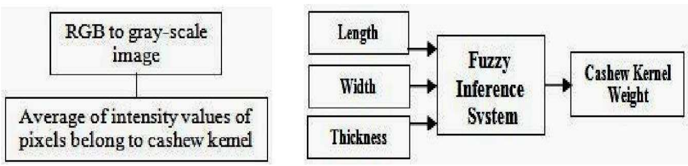
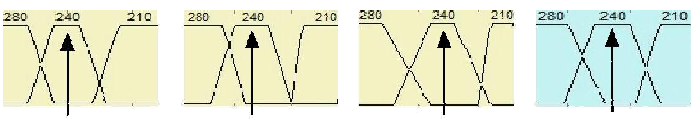


Figure 7. (a) Color information extraction (b) Fuzzy inference system



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

Figure 8. Application of AND operator in rules

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.

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. 8.

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.

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.

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.**

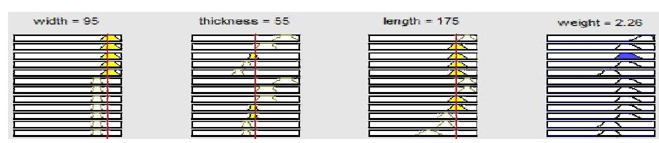


Figure 9. Rule viewer

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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