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A Survey Paper On Cashew Kernels Classification Using Color Features & Computer Revelation System.

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Abstract

Cashew is a commercial commodity that plays a major role in earning foreign revenue among export commodities in India. The purpose of this research work is to explore image processing techniques and approaches on Indian cashew variety identification based on their kernels. Color is an important quality factor for grading, marketing, and end users. Our primary objective is to develop a cost-effective intelligent model to identify the cashew kernels. Colour features in the RGB (red-green-blue) color space are extracted and computed. A feed-forward neural network is trained to classify sample cashew kernels. An intelligent classification system based on computer vision system can be developed for automated grading and sorting to speed up the classification of cashew kernels. This will solve the major problems of many of the cashew export industries also, gives justice to the cashew growing farmers in accurate grading. The classification system is evaluated on cashew kernels of 6 different grades. The result of our study shows that, the system gives about 80% classification rate. Computer vision has been successfully adopted for the quality analysis of meat and fish, pizza, cheese, and bread. Likewise grain quality and characteristics have been examined by this technique. This paper presents the significant elements of a computer vision system and emphasizes the important aspects of the image processing technique coupled with a review of the most recent developments throughout the food industry.

Keywords: Image Processing, Color features, cashew kernel, grading, Neural Network.

Introduction

Cashews are most widely grown crop of India especially in coastal areas. In the recent years, Cashew is a commercial commodity that plays a major role in earning foreign currency among export commodities in India. The Assessment of cashew quality is the function of government agency entrusted to perform cashew kernel grading and it is important for the cashew export industry. The grading operation is important, as it is the last opportunity for quality control on the kernels. With the exception of a few grading aids, all grading is being done by manually. In the present international market scenario, it is very much essential to keep our products well graded automatically to compete in the market place. For large operations looking towards export markets, it is necessary to grade the kernels to an international level. India, the largest exporter & distributor of Cashew Nuts in the world, cashew nut are of the highest quality and has helped in gaining repute amongst all in the international market.

Grading of cashew kernels is based on inspection of physical quality attributes such as color, shape, and size. By using these physical attributes, a trained person determines the cashew kernel of which class (i.e. white wholes). The Table 1 illustrates the Grade designations and definitions of quality of cashew kernels (i.e. white wholes). Reference color slides are available to assist with the assessment of cashew kernel color. Despite the training of grading personnel and the availability of reference slides, the current methods for cashew kernel quality evaluation is time consuming, tedious, and inherently inconsistent. An objective and cost–effective computer vision system is needed to segregate cashew kernels. Such a system would not only facilitate cashew grading but also serve as a quality control tool for processing facilities such as elevators, seed cleaning plants, and oil mills.

There have been successful applications of computer vision in agricultural product inspection, but most efforts are still in the research and development stage. Research Endeavour's have grown rapidly in the past 10 years. Extracting various morphological, tonal, textural, and color features for classification of grains by variety, grades, and damage has been the focus of the reported research and only a few researchers have reported work on soybean[5].

The objective of this study was to determine the usefulness of color features of cashew kernel images in classifying them into white wholes categories. The research entailed the development of an algorithm to segment images of cashew kernels of different shades and colors. The proposed work emphasizes on development of Artificial Neural Networks (ANN) based method for automatic classification of cashew kernel samples instead of using color histograms. Color histograms have several inherent limitations for the task of image indexing and retrieval. The images of the cashew kernel were snapshot by a high-resolution (5-megapixel) Sony digital color camera (Model DSCV3). The cashew kernel images were then segmented, isolating the region of interest from the background and 15 color parameters were extracted for to identify the particular grading of cashew kernel categories. The 15 distinguishable features are mentioned in Table 2. The parameters obtained were used to train a neural network created. Once trained, the network was tested with other cashew kernel for the desired results. All these programs were developed using MATLAB 7.8 version.

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. This system known as computer vision has proven to be successful for objective measurement of various agricultural (He, Yang, Xue, & Geng, 1998; Li & Wang, 1999) and food products (Sun, 2000; Wang & Sun, 2001).

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 performed 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.

Fundamentals of computer vision

Following its origin in the 1960s, computer vision has experienced growth with its applications expanding in diverse fields: medical diagnostic imaging; factory automation; remote sensing; forensics; autonomous vehicle and robot guidance.

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).

Hardware

Computer vision system generally consists of five basic components: illumination, a camera, an image capture board (frame grabber or digitiser), computer hardware and software as shown in Fig. 1 (Wang & Sun, 2002a).

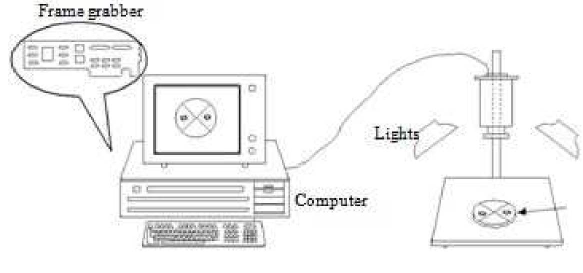


Fig. Components of a computer vision system (Wang & Sun, 2002a).

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. Vari-ous 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 collection process is considered of importance with most modern systems having built in compensatory circuitry.

Image Processing and Image Analysis

Image processing and image analysis are recognised as being the core of computer vision (Krutz, Gibson, Cassens, & Zhang, 2000). Image processing involves a series of image operations that enhance the quality of an 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 sys-tems 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 ope-ration 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-casses (Park & Chen, 1994).

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. Segmentation can be achieved by three different techniques: thresholding, edge-based segmentation and region-based segmentation as shown in Fig. 3 (Sonka et al., 1999; Sun, 2000).

Thresholding is a simple and fast technique for characterizing image regions based on constant reflectivity or light absorption of their surfaces. Edge-based segmentation relies on edge de-tection by edge operators. Edge operators detect dis-continuities in grey level, colour, texture, etc. Region segmentation involves the grouping together of similar pixels to form regions representing single objects within the image. The criteria for like-pixels can be based on grey level, color and texture. The segmented image may then be represented as a boundary or a region. Boundary representation is suitable for analysis of size and shape features while region representation is used in the evaluation of image texture and defects. Image des-cription (measurement) deals with the extraction of quantitative information from the previously segmented image regions. Various algorithms are used for this process with morphological, textural, and photometric features quantified so that subsequent object recognition and classifications may be performed.

High level processing involves recognition and interpretation, typically using statistical classifiers or multi-layer neural networks of the region of interest. These steps provide the information necessary for the process/ machine control for quality sorting and grading.

The interaction with a knowledge database at all stages of the entire process is essential for more precise decision making and is seen as an integral part of the image processing process. The operation and effectiveness of intelligent decision making is based on the pro-vision of a complete knowledge base, which in machine vision is incorporated into the computer. Algorithms such as neural networks, fuzzy logic and genetic algo-rithms are some of the techniques of building knowledge bases into computer structures. Such algorithms involve image understanding and decision making capacities thus providing system control capabilities. Neural net-work and fuzzy logic operations have been implemented successfully with computer vision in the food industry (Ying, Jing, Tao, & Zhang, 2003).

Proposed System

The system acquires images of the cashew kernel and this forms an input to the image-processing unit that extracts the necessary features of the cashew kernel in "Fig.(1)". The features obtained were the inputs to the neural network, the network is trained using supervised learning to recognize cashew kernel of category White Wholes. To test the network, 6 sets consisting of all white wholes category of each 10 cashew kernels were used.

Materials And Method

Experiment Samples

Cashew kernel samples were obtained from the Karnataka Cashew Board, Mangalore District, Karnataka State. The samples included cashew kernels of white wholes class. Cashew inspectors manually classify the kernels. Examples of cashew kernels are shown in "Fig.(2)".

Collection of sample Images

A high-resolution (5-megapixel) Sony digital colour camera (Model DSCV3) was utilized. The captured images were obtained as JPEG image files. The cashew kernel samples were photographed at a particular position at specific lighting conditions. The images are likely to have a high resolution since it yields a better image processing result. An example of a sample jpeg image of a Cashew kernel is shown in "Fig (2)".

Image Segmentation

Image segmentation refers to the process of delineating the regions or objects of interest in an image. For this work, the cashew kernel must be isolated from the background before they could be characterized. The first step in image analysis is to find objects. For this, object color must be different from colored foreground, based on a given color threshold set by the user. Thresholding is an important part of image segmentation. The threshold value is generated according to the results of the histogram analysis and was constant for the same environment conditions. This results in a black and white (binary) image from the color image, where background pixels are painted black and objects painted white. The image must retain the colour information of the cashew kernel when segmentation was processed. All the pixels with intensity value greater than 35 were assigned the value 255, and all pixels with intensity value less than or equal to 35 were not processed in any operation [2]. For the technology to be practically useful, the segmentation algorithm needs to be fast and capable of handling variations in cashew kernels. The input data will be an image consisting of multiple nuts, so the first step is to segment this image in order to view and extract features from each individual nut separately. The problem is simplified by considering only the grey-scale image "Fig. (3)" rather than a 3- dimensional color image. Due to the nature of the contrast between background and foreground, a thresholding technique has been applied in order to create a binary image: i.e. all nut pixels are represented as '1' and all background pixels are represented a '0' ("Fig. (3(c))").

The value of a suitable threshold has been determined empirically. In this form it becomes straight forward to identify each region by examining groups of connected pixels, and labelling the region appropriately (as shown in "Fig. (3(c))"). A labeled region can be segmented by ignoring all the other labeled regions ("Fig. (3(d))"). Once segmentation process is over, the image data for each individual nut is stored in a structure array with the following fields:

CASHEWS. color- N-by-M-by-3 color image of nut
CASHEWS. grey- N-by-M grey-scale intensity image of nut
CASHEWS.bw - N-by-M binary mask

CASHEWS. Label- string containing the class label.

Feature Extraction

Image features of the cashew kernels were extracted to characterize the physical quality attributes of cashews. A number of color features were computed and tested. They included the means and standard deviations of R, G, and B(red, green, and blue); the means of H, S, and I (hue, saturation, and intensity); excess red (2R–G–B), excess green (2G–R–B), and excess blue (2B–R–G). The excess colors correspond more closely to the way humans perceive colors than the RGB representation [4]. Also the other feature has been investigated as morphological characteristics of cashew kernel. Algorithms were developed in Windows environment using Matlab 7.8 programming tools to extract color features of individual cashew kernel. From the red (R), green (G), and blue (B) color bands of an image, hue (H), saturation (S), and intensity (I) were calculated using the following equations[5]

Conclusion

The results of this study show that color 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.

The classification accuracy was acquired under laboratory setting, so it had some limits. In future work, a large quantity of cashew kernels will be investigated.

Grade	Count per 454 gms	General Characteristic
W-180 W-210 W-240 W-320 W-450 W-500	170-180 200-210 220-240 300-320 400-450 450-500	Cashew kernels shall have been obtained through shelling and peeling cashew nuts. Shall have the characteristic shape; shall be white, pale ivory or light ash in colour reasonably dry and free from insect damage, damaged kernels and black or brown spots. The kernels shall be completely free from testa.

Table -1 Cashew Kernels (White Wholes)

Table -2 Extracted Features

S.N	Features	S.N	Features
1	Red mean	9	Saturation mean
2	Red standard deviation	10	Saturation standard deviation
3	Green mean	11	Intensity mean
4	Green standard deviation	12	Intensity standard deviation
5	Blue mean	13	Excess red mean
6	Blue standard deviation	14	Excess green mean
7	Hue mean	15	Excess blue mean
8	Hue standard deviation		

Table -3 Classification Results for 'White Wholes'

S. No.	Grade	No. of samples tested	No. of samples classified correctly	% of classification on obtained
01	180	20	19	95.00
02	210	22	20	90.90
03	240	20	17	85.00
04	320	20	18	90.00
05	450	10	08	80.00
06	500	10	04	40.00

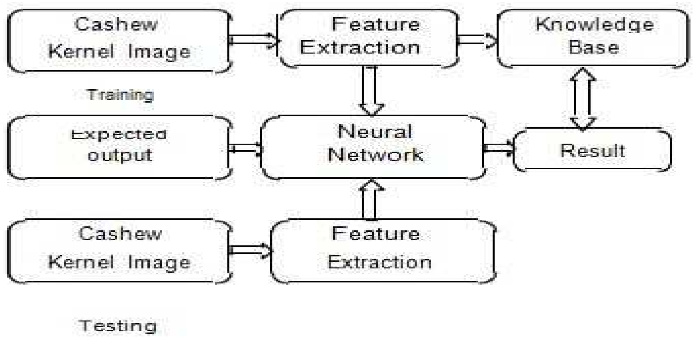


Fig. -1 Block diagram of the system for classification of cashew kernels.

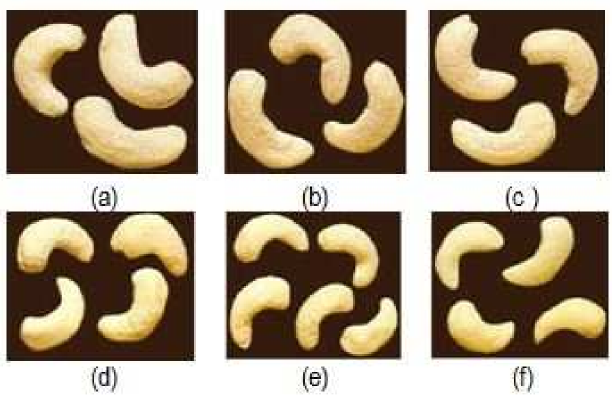


Fig.-2 Images of cashew kernels (a) White wholes-180 (b) White wholes-210 (c) White wholes-240 (d) White wholes-320 (e) White wholes-450 (f) White wholes-500

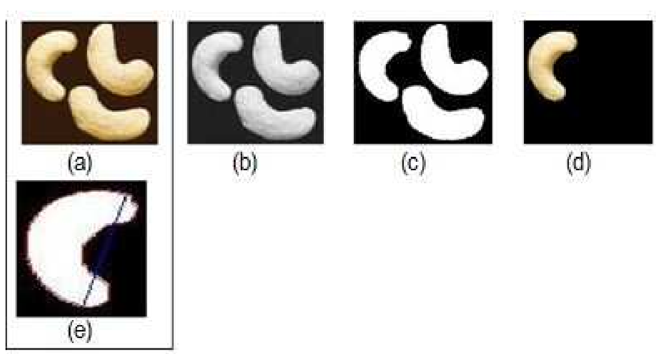
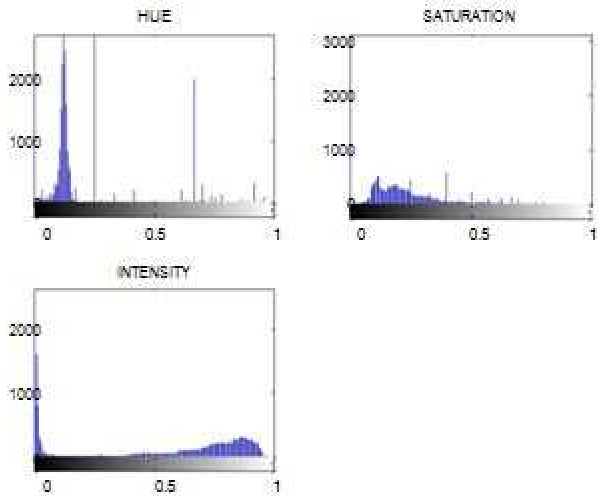


Fig. -3 (a) Cashew Kernel (b) Gray-scale image (c)Mask (d) Individual Cashew kernel (e) Individual Mask



(a)

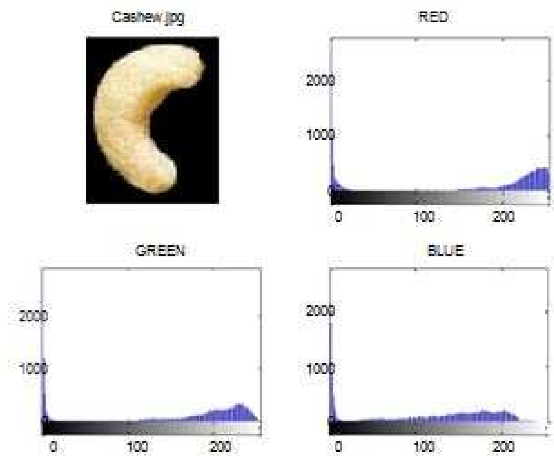


Fig. -4 Histograms of (a) RGB and (b) HIS components of Cashew kernel

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