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Automated Fruit Quality Assessment Via Near Infrared Spectroscopy

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Abstract:
Over the last couple of decades, with the rapid development of the economy and improvement of living standards, fruit consumption has increased significantly. Meanwhile, consumers have higher expectations of fruit qualities such as ripeness, firmness, soluble solids content (SSC) and acidity. However, many fruit quality attributes affecting consumer acceptance and price are still tested using traditional approaches which are either subjective or time-consuming. Moisture content influences taste, texture, weight, appearance and shelf life of foodstuffs. Even the slight deviation from the defined standard can adversely impact the physical properties of the foodstuffs. NIR methods have been widely used to detect the quality of fruits and vegetables since the NIR optical components (source and detector) are affordable. NIR spectroscopy deals with irradiating the product with NIR light (750 nm to 2500 nm) and with collecting and analysing the spectrum using spectrum analyser. Transmittance method measures transmitted light through tissues and thus it gives information about overall quality of fruits. In this work, NIR based imaging is used to measure the moisture content of the fruits for determining quality.

Keywords: NIR, Automation, Fruit Quality, Grading, Image processing, Signal Processing.

I. INTRODUCTION

India is an agriculture country. Different types of fruits and vegetables are produced in India. India is at second number after china in production of fruits. In India all the pre-harvest and post-harvest process are done manually with help of labor. Manual process is very time consuming, less efficient so to get accurate result automation in agriculture industry is needed. The post- harvest process includes sorting and grading of fruits. Different quality factors are considered for sorting and grading of fruits. These factors are internal quality factors and external quality factors. The external quality factors are texture, shape, color ,size and volume, and internal quality factors are taste, sweetness, flavor, aroma, nutrients , carbohydrates present in that fruit [3]. Automation is playing important role in day today life. In India more than half population depends upon agriculture. Their main source of income is agriculture. Exporting of fresh fruit is increased day to day from India. People are very conscious about their health; they prefer only fresh, good quality fruit. With increased expectations for food products of high quality and safety standards, the need for accurate, fast and objective quality determination of these characteristics in food products continues to grow. 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. Considerable research has highlighted its potential for the inspection and grading of fruits and vegetables. Image processing is a method to convert an image into digital form and perform some operations on it, in order to get an enhanced image or to extract some useful information from it. It is a type of signal dispensation in which input is image, like video frame or photograph and output may be image or characteristics associated with that image. Usually Image Processing system includes treating images as two dimensional signals while applying already set signal processing methods to them. It is among rapidly growing technologies today, with its applications in various aspects of a business. Image Processing forms core research area within engineering and computer science disciplines too. The field of a digital - image processing has experienced dramatic growth and increasingly widespread applicability in recent years. Fortunately, advances in computer technology have kept pace with the rapid growth in volume of image data in these and other applications. Digital image (signal) processing has become economical in many fields of research and in industrial and military applications. While each application has requirements unique from the others, all are concerned with faster, cheaper, more accurate, and more extensive computation. Analysis of document images for information extraction has become very prominent in recent past. Wide variety of information, which has been conventionally stored on paper, is now being converted into electronic form for better storage and intelligent processing. This needs processing of documents using image analysis, processing methods. This article provides an overview of various methods used for digital image processing using three main components: Preprocessing, Feature extraction and the Classification. Preprocessing includes Image acquisition, Binarization, identification, Layout analysis, feature extraction and classification. Classification is an important step in Office Automation, Digital Libraries, and other document image analysis applications. This article examines the various methods used for document image processing in order to achieve a processed document having high quality, accuracy and fast retrieval.

II. LITERATURE SURVEY

H. Alimohammdi *et al* (2013)[5] designed a system for skin defect detection in fruits. Gabor wavelet Filter is used for defect detection. Convert color image into texture image and then on that image Bank of Gabor filter is applied. Gabor

Filter is linear filter and used as edge detector. Gabor filters with 4 scales and 6 rotations used in this paper. Obtained response shows image pixel is as defected or normal skin. Optimal filter is chosen from bank of Gabor filters depending upon the response . Thresholding the response of the optimal filter. Based on thresholding skin defect is detected. [**1**] Y. Wang *et al* (2010) [2] designed a system in which Fruit quality inspection is done based on fruits surface color. It is non destructive method. Fruit image is captured with camera, RGB image is converted into the HSI color model. Image is segmented based on hue value ,separate fruit and its background. Histogram of Hue and Saturation of fruits surface color is calculated. Input is given as histogram, output obtained earlier of Hue and Saturation of surface color of fruit from back propagation network. Output as quality description of given tested fruit. They performed experiment on banana and result obtained is accurate. S. A. Khoje *et al* [3] developed a system of fruit grading for automated skin defect identification using Discrete Curvelet Transform. Discrete Curvelet transform is used for texture analysis. Multi resolution approach is used in DCT, By using low and high resolution capability local and global features of that fruit are found. Energy, entropy, mean and standard deviation of each good and defected fruit is calculated these are called as features.. Support vector machine and Probabilistic neural network for classification of good fruits and defected fruits. Based on obtained result SVM is more accurate than PNN [3-5]. M. Satpute *et al* [4] in this paper different technique of color, size, shape, texture and volume detection of fruit are discussed Fengqing Zhu, *Member*, *IEEE*, Marc Bosch, *Member*, *IEEE*, Nitin Khanna, *Member*, *IEEE*, Carol J. Boushey and Edward J. Delp, *Fellow*, *IEEE*, **"Multiple Hypotheses Image Segmentation and Classification With Application to Dietary Assessment"** in IEEE Journal Of Biomedical And Health Informatics, VOL. 19, NO. 1, JANUARY 2015.[6- 8]This proposed a method for dietary assessment to automatically identify and locate food in a variety of images captured during controlled and natural eating events. Two concepts are combined to achieve this: a set of segmented objects can be partitioned into perceptually similar object classes based on global and local features; and perceptually similar object classes can be used to assess the accuracy of image segmentation.

These ideas are implemented by generating multiple segmentations of an image to select stable segmentations based on the classifier‟s confidence score assigned to each segmented image region. Automatic segmented regions are classified using a multichannel feature classification system. For each segmented region, multiple feature spaces are formed. Feature vectors in each of the feature spaces are individually classified. The final decision is obtained by combining class decisions from individual feature spaces using decision rules. We show improved accuracy of segmenting food images with classifier feedback.

III. OVERVIEW

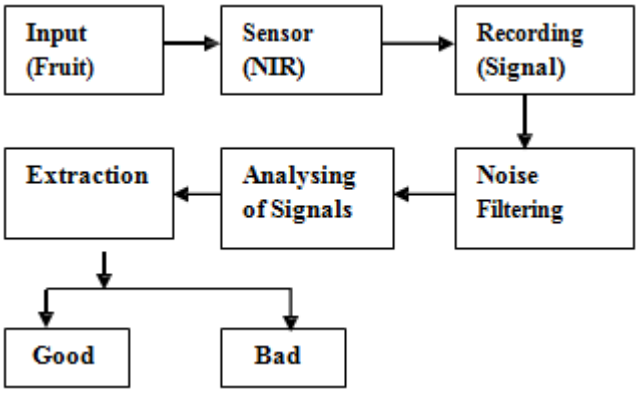
Image acquisition in image processing can be broadly defined as the action of retrieving an image from some source, usually a hardware-based source, so it can be passed through whatever processes need to occur afterward. Performing image acquisition in image processing is always the first step in the workflow sequence because, without an image, no processing is possible. The image that is acquired is completely unprocessed and is the result of whatever hardware was used to generate it, which can be very important in some fields to have a consistent baseline from which to work. One of the ultimate goals of this process is to have a source of input that operates within such controlled and measured guidelines that the same image can, if necessary, be nearly perfectly reproduced under the same conditions so anomalous factors are easier to locate and eliminate.

The first stage of any vision system is the image acquisition stage. It is obvious to all that image (and signal) processing has become an exceedingly important and hot topic that cuts across many areas: engineering, physical science, computer science and of course mathematics.

Less obvious, but becoming increasingly well known, is that signal and image processing are getting great improvements in performance by using wavelet based methods. In an effort to achieve better understand the wavelet based methods and image processing itself, I will give a series of talks that introduce wavelet based image processing methods in the context of traditional image processing. The plan is to have about four talks that roughly cover the following. Introduction to image processing and image processing problems: restoration, compression and denoising. Filtering and Fourier methods. Localization, wavelet and windowed transforms. Filter bank implementation of wavelet based methods.

IV. PROPOSED SYSTEM

A. Block diagram



B.Description

The fruit is placed on the sample testing place. The Infrared Sensor is placed upon the fruit for direct testing. The sensor radiates the fruit with Infrared radiation. The signal reflected from the fruit is recorded and visualised by software SigView. The recorded wave is stored and Image (Signal) processing is done on the software-Matlab.

C. Processing Flow

(i) Recording of Wave

The fruit is irradiated by the Infrared LED and the reflected wave is detected by the sensor. For capturing the reflected wave effectively, necessary precautions were made.

(ii) Denoising

The recorded wave is denoised using Matlab Software. The wave is reconstructed using the Short Time Fourier Transform Algorithm. The resynthesised signal is used for further analysis.

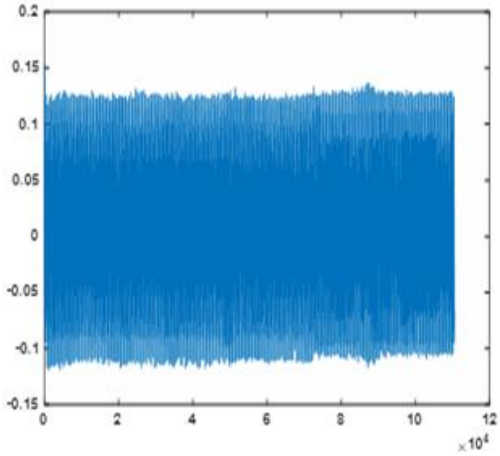


Figure.2. Reconstructed Signal

(iii) Analysis of Signals

Various Analysis were performed on the reconstructed Signal. Mean, Standard deviation and other statistical values obtained from the probability distribution of the signals are used for the analysis.

A. Decomposition of Signal

The signal decomposition is mainly extraction and separation of signal components from composite signals. Signal decomposition methods are closely related to classification of underlying features, which charecterize the component to be separated. An impotant category of signal decomposition methods is segmentation of image, video,audio and speech sigals, which is often a prerequisite for useful feature extraction and classification, but can also be used to improve the performance of compression algorithms.

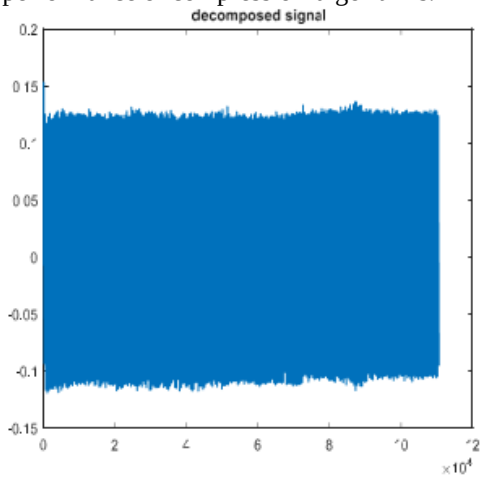


Figure.3. Decomposed Signal

Wavedec2 is a two-dimensional wavelet analysis function. [C,S] = wavdec2(X,N, „wname‟) returns the wavelet decomposition of the matrix X at level N, using the wavelet named in character vector „wname‟.Outputs are decomposition vector C and the corresponding bookkeeping matrix S. Matrix S is such that S(1, :) =size of approximation coefficients(N). S(i, :) = size of detail coefficients (N-i+2) for i=2,…N+1 and S(N+2,:) =size (X).

Wavelet packet decomposition

Originally known as Optimal Subband Tree Structuring (SB-TS) also called Wavelet Packet Decomposition (WPD) (sometimes known as just wavelet Packets or Subband Tree) is a wavelet transform where the discrete-time (sampled) signal is passed through more filters than the discrete wavelet transform (DWT). In the DWT, each level is calculated by passing only the previous wavelet approximation coefficients (cAj) through discrete-time low and high pass quadrature mirror filters. However, in the WPD, both the detail (cDj (in the 1-D case)) and approximation coefficients are decomposed to create the full binary tree. Discrete wavelet transform theory (continuous in the variables(s)) offers an approximation to transform discrete (sampled) signals. In contrast, the discrete subband transform theory provides a perfect representation of discrete signals. From the point of view of compression, the standard wavelet transform may not produce the best result, since it is limited to wavelet bases that increase by a power of two towards the low frequencies. The best basis algorithm by coifman and wickerhauser finds a set of bases that provide the most desirable representation of the data relative to a particular cost function (e.g. entropy).

C. Spectrum analysis

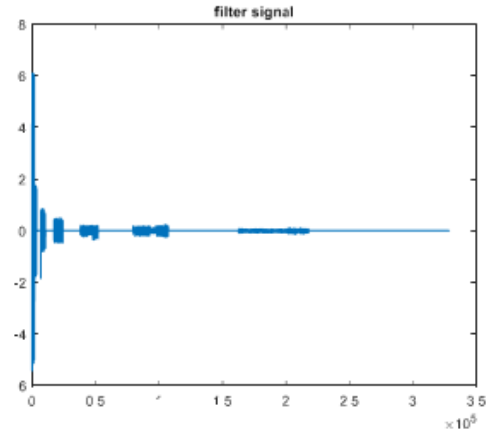


Figure.4.

B. Autocorrelation

Autocorrelation, also known as serial correlation of a signal with a delayed copy of itself as a function of delay. Informally, it is the similarity between observations as a function of the time lag between them. The analysis of autocorrelation is a mathematical tool for finding repeating patterns, such as the presence of a periodic signal obscured by noise, or identifying the missing fundamental frequency in a signal implied by its harmonic frequencies. It is often used in signal processing for analysing functions or series of values, such as time domain signals. In signal processing, the above definition is often used without the normalization, that is, without subtracting the mean and dividing by the variance. When the autocorrelation function is normalized by mean and variance, it is sometimes referred to as the autocorrelation coefficient or autocovariance Function.

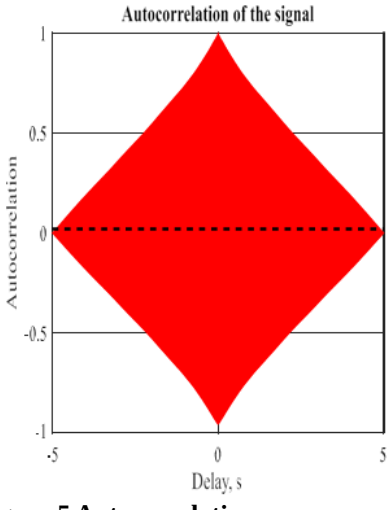


Figure.5 Autocorrelation

In spectrum analysis of audio signals, we nearly always analyse a short segment of a signal, rather than the whole signal. Perhaps most fundamentally, Fourier analyses only a short segment of audio signals at a time (on the order of 10-20 ms worth). Therefore, to perform a spectrum analysis having time- and frequency-resolution comparable to human hearing, we must limit the time-window accordingly. We will see that the proper way to extract a "short time segment" of length N from a longer signal is to multiply it by a window function such as the Hann window: $w(n)=\cos^2(n\pi/N)$, n= - N-1/2,…,-1,0,1,…N-1/2 The Hann window can be seen as one period of a cosine "raised" so that its negative peaks just touch zero (hence the alternate name "raised cosine"). Since it reaches zero as its endpoints with zero slope, the discontinuity leaving the window is in the second derivative, or the third term of its Taylor series expansion at an endpoint. As a result, the side lobes roll off approximately 18 dB per octave.

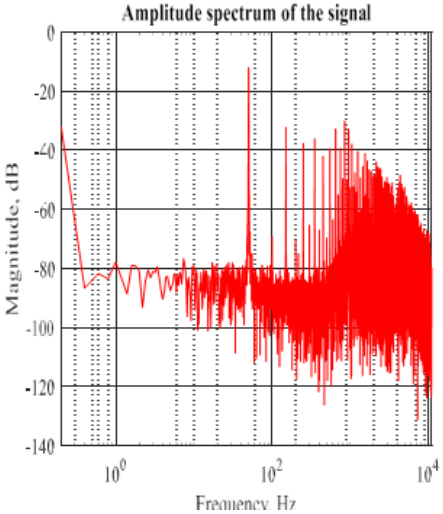


Figure.6.

V. CONCLUSION

In this paper, the quality inspection of fruit is discussed using signal processing of Near Infrared Spectroscopy. The test performed on apple for moisture analysis of the fruit. This test is performed for fruit varieties having thin peel. The signal is analysed with various parameters including statistical data like mean, standard deviation, Autocorrelation and the other signal parameters like peak factor, Dynamic range.

VI. FUTURE SCOPE

Further design can be modified by increasing the irradiating part of the sensor. The other way can be using the Transmittance property of Spectroscopy by using the Spectrometer for higher quality inspection and increase accuracy of the system. Moisture Analyser can be used for further analysis.

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