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Machine Vision System for Tea Quality Determination - Tea Quality Index (TQI)

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Abstract: - Fermentation process plays an important role in tea manufacturing which is responsible for deciding the final quality of tea. But, during fermentation, it is always not possible to check the tea grains quality in uniform manner because of heavy lot of material. Also human access to the process is not advisable as the whole lot of material can not be tested with uniformity. Color and size appearance of tea grains may give substantial information regarding the tea quality and this has been harnessed in the proposed work. A machine vision system offers a fair solution in order to solve this problem. It is proposed to explore the possibility of testing the color of tea during the fermentation process imaging by a digital camera and then by using the red, green and blue (RGB) color model. An application such as color matching in fermented tea can be accomplished accurately in spite of the variation in illumination, color and internal reflection in the camera, by using a specific imaging setup of constant illumination and camera direction and distance. An algorithm is proposed to be designed that evaluate the color of the fermented tea during the process and produce the histogram (RGB as well as gray) so that the color based inference could be resulted out. A Tea Quality Index (TQI) is proposed also by applying Image Processing techniques on acquired Images of tea grains. For determination of TQI, very firstly, the average size of grains in image is computed by applying size estimation algorithm and then the diameter, area and perimeter of each grain are determined. Then after, a TQI is computed with appropriate weights to the grain dia, perimeter, area and average color. Further, TQI may be fine tuned by inserting more tea grain parameters when extracted in future.

Keywords: - *Tea quality, Histogram, Color dissimilarity, Granule size*

I. INTRODUCTION

The color, size and shape of processed foods such as sugar, tea, juice, jelly, jam, chips, chocolates etc. are important parameters for determining the quality of the product. Measurement of these color and size plays an important role in the food processing industry. They can be treated as critical quality parameters and become useful when indexing the quality of raw and processed foods, and for analysis of quality changes as a result of processing, storage or any other factors. Therefore, these parameters represent meaningful data and can act as a means of quality control of the products. As technology advances the food-processing industries try to modernize their processing technology so as to improve the quality of food products, increase productivity and save energy. Quality control and automation is achieved by measurement and monitoring process parameters. Online/offline determination of product color is one of the advanced techniques of quality control.

Black tea is an important high value crop worldwide. Production of black tea involves certain well-defined processing stages governed by many parameters. Due to lack of an advanced quality monitoring technique tea industry has been facing difficulties in producing good quality tea. The tea producers seek to modernize their production techniques to satisfy a customer demands for products with greater consistency, better flavour and product differentiation. This has promoted the exploration of the use of techniques to improve quality through monitoring during the manufacturing process.

II. RELATED WORKS

Quality of tea sets its market value. In Indonesia, the black tea standard quality evaluation refers to Indonesian National Standard (SNI) of black tea 01-1902-1995. For image acquisition process, standard box with illuminator and digital microscope with 5x magnification were used to capture the detail of tea grains. In this evaluation, 284 gram particles approximately consists of 1000 granular particles was used. Parameters of each particle such as Area(A), Perimeter(T) and bending Energy(E) were determined by Morphology operation. Furthermore, the particles' Image color histogram on red(R) and blue(B) channels was applied for extraction of Color information. Feature sets are consist of T/A, E, R and B parameter values, certain interval of histogram represent each parameter value and uniformly applied in all feature set..[1]

Suitable steaming of tea leaves is an important process in the tea manufacturing. In this paper, method of feature extraction from tea leaves is used for measuring the degree of the steaming. Changes in shape and color of tea leaves and central veins gradually stand out by the steaming. Therefore, the contrast between color of the central vein and its surrounding areas is adopted to measure the degree of the steaming. This paper use image processing techniques to detect central veins of tealeaves and analyze the feature of contrast.[2]

Tea manufacturing process basically observed with human eye vision. Electronic vision is very helpful to observe all process in tea manufacturing. Infusion is a very important process for good quality of black tea. Some change occurs during infusion, green color convert into a dark brown color, odor changes in some fruity odor and due to some complex chain reaction of biochemical enzymes subsequently inside the macerated tea leaf.[3]

For determining the Tea Quality, the design and development of a personal computer (PC) based system is used for monitoring changes in color during the fermentation process. The technique is based on capture images of the fermenting tea at regular intervals of time and processing the color images. A digital camera, along with a specific lighting arrangement, was used to capture color images during the fermentation process. The Histogram dissimilarity measurements of RGB color model was used so that matched the color of test images to a standard image color. This dissimilarity measurement was represented by difference from the Manhattan norm (L1). This technique was compared with the visual methods used by expert tea tasters.[4]

Traditionally the organoleptic method of tea testing has been used for quality monitoring, an alternative way is by machine vision. The three main quality descriptors estimate the overall quality of made-tea, viz., strength, briskness and brightness of tea liquor, but the exact color detection in fermenting process leads to a good quality-monitoring tool. The use of digital image processing technique is an effective the production of good quality tea. In this paper, there is compare the contribution of the chemical constituents towards the final product with the visual appearance in the processing stage by imaging. The use of machine vision supports the process somewhat invariantly in comparison to the human decision and colorimetric approach.[5]

Theaflavins (TF) and thearubigins (TR) are the two important chemical compounds, which contribute to the brightness and color of tea liquor. Spectrophotometer is generally used for estimation of TF and TR in black tea. But, this technique undergoes more time consuming, also the operation of spectrophotometer is costly and requires expert manpower. To overcome above drawbacks an Image processing based electronic vision system has been developed, which is faster, low cost, repeatable and can estimate the amount of Total Color (TC), Brightness (TB), Theaflavins (TF) and TF/TR ratio for orthodox tea liquors.[6].

This paper use machine vision system for investigates optimum light illumination intensity for maximum discrimination of the Indian black tea varieties. This technique involves acquisition and analysis of color information of brewed tea liquor after setting different light illumination intensities between 700 and 1,300 lux. The data involving color attributes was analyzed using principal component analysis system. [7].

Tea good quality plays an important role in its marketability. Traditionally, organoleptic methods such as inspection by human sensory panel, and instrument based approaches such as gas chromatography and colorimetric method have been quality monitoring tools in various stages of tea processing. These methods are time consuming, expensive, laborious and sometimes inaccurate.[8]

Fermentation is a crucial process in black tea manufacturing which is responsible for deciding the final quality of tea. During fermentation, grassy smell gets transformed to floral smell and green tea changes its color from green to coppery brown. This paper presents a study of monitoring volatile emission pattern during black tea fermentation process by electronic nose-based and detection of the optimum fermentation time on the basis of peaks in the sensor outputs.[9]

Fermentation is a crucial stage for black tea quality and this stage is responsible to make better quality black tea in the sense of appearance, aroma, liquor and infusion. During fermentation greenish color changes into the coppery brown and grassy smell continues change to the floral smell due to some complex chain of biochemical reaction inside the tea leaf. [10]

Vital task in the tea industries is Tea color determination during fermentation. Traditionally, measurement of change in color during fermentation by human experts by picking up some amount of tea sample and observing the color by eye approximation. Colorimeter method is also used for determining the color during fermentation. The paper describes the imaging setup, color matching algorithm and comparison of the results with conventional manual methods.[11]

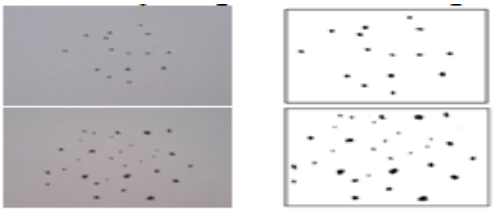
Tea tasting is predominantly controlled by human experts known as "TEA TASTERS". Major components in determining the quality of tea are Aroma, flavor and color. In today world the advancement of various image processing techniques with the help of PC can result as boon for tea industries. In this paper,

various components of intelligent system engineering are applied for the color analysis of black tea. This paper emphasizes on a brief description of image capturing technique, illumination arrangement and color evaluation using L*ab color model.[12]

This paper presents image processing and artificial intelligence techniques for tea color determination. The aim of this research is to identify the stalk particles which reduce the quality of tea, without removing good particles with the intention of increasing the quality of the tea during manufacturing process. In order to achieve this aim it is important to identify the positions of the stalk particles. Several methods were tested for solving this problem including thresholding the image according to pixel values and a fuzzy system. 13]

III. TEA GRAINS IMAGE ACQUISITION

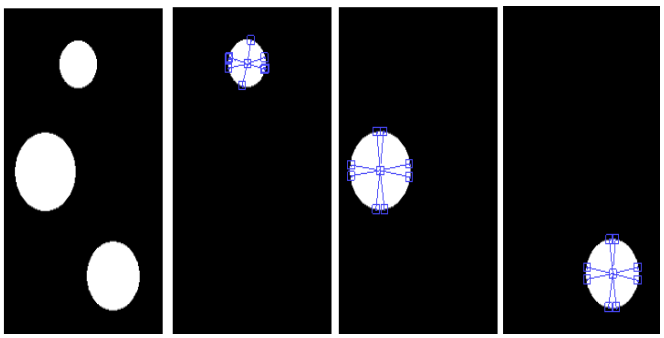
The tea grains images are acquired by using the CCD camera. The jpeg images are then converted to gray scale image. The gray scale image are exposed to Otsu algorithm for thresholding. This converts the gray scale image into binary image i.e. black being the tea grains and white being the back ground.



Orig. Image Binary Image

IV. GRAIN SIZE SEGMENTATION

Tea grains are segmented by encoding the binary image using the run-length procedure. The encoded image is then scanned and assigns the preliminary labels and records label equivalences in a local equivalence table. The equivalence classes are resolved based on 8-connectivity of the pixels and labels the scanned image is relabeled for final segmentation. The mentioned algorithm can be implemented directly by using the matlab command bwlabel that works on the same. By applying the bwlabel command on binary image, following results are obtained:



Binary Image Seg. # 1 Seg. # 2 Seg. # 3

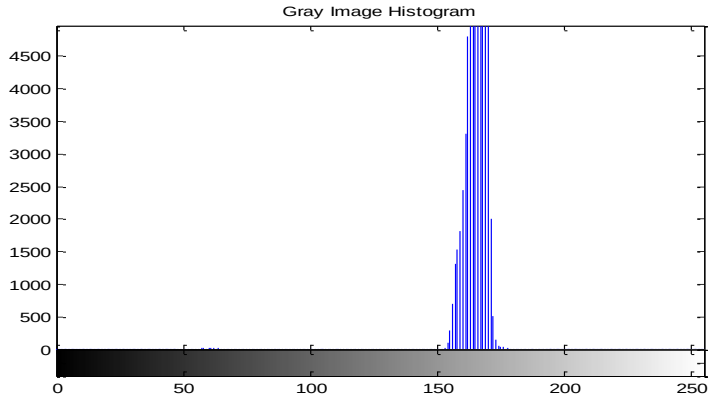
V. GRAIN SIZE DETERMINATION

1. Image Acquisition: A digital camera (CCD Camera), together with a special lighting arrangement, installed on top of fermented Tea is used to capture color images during the fermentation process.
2. RGB to Gray Conversion: Captured RGB Image by digital camera is in JPEG format is converted into Gray Scale format.
3. Gray Image Histogram Extraction: From Gray Image Histogram Prime Color of the Tea is extracted.
4. Image Enhancement: Now Image has to be Enhanced using Histogram Equalization.
5. Image Zooming: Further the Image is zoomed out using Image Processing.
6. Threshold: The zoomed Image is Threshold to get the Binary Image or Black & White Image.
7. Size estimation: Binary Image contains Tea Grains
8. in bigger size from which we can easily estimate the Size of Grain.
9. Segmentation of Image: Black & White Image is now segmented using the Segmented Algorithm thereby giving single Tea Grain in single Window.

10. Now, feature/Size estimation Algorithm is applied on Segmented Tea Grain.
11. Once Size of each Grain is computed, the Average Size of Tea Grain is calculated.
12. Same steps from 5 to 10 are repeated for next Block of Image.

VI. AVERAGE COLOR ESTIMATION

- Scan the image in raster scan order.
- Extract the pixel color value.
- Keep on adding each pixel color value.
- Increment the pixel counter.
- Compute the average pixel color.
- Compute the average tea color by multiplying the av. Color by red component factor i.e. 0.2989.

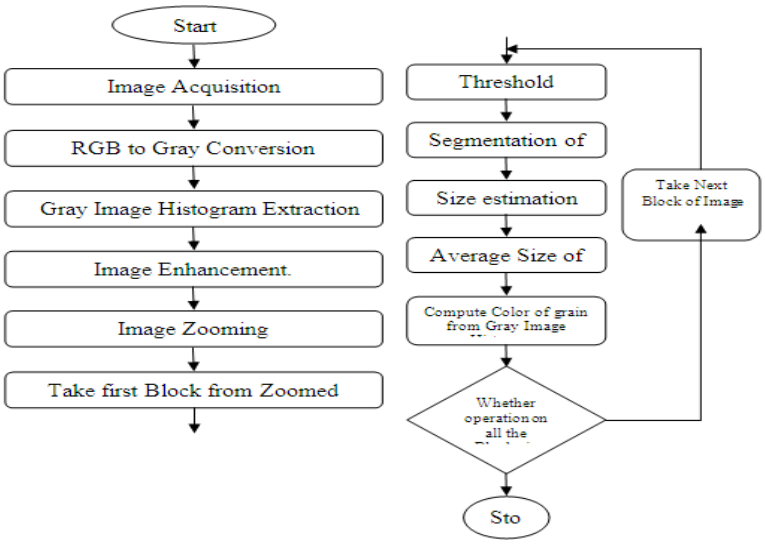


VII. RESULTS

The result table is compiled by applying the discussed algorithm over different known tea grade qualities:

Test Samples	Area_SD	Dia. SD	Perimeter_SD	RedComp.	BlueComp	TQI	Quality
A	6.23	0.63	2.29	49.97	19.03	78.11	Excellent
B	8.24	1.51	5.1	48.53	18.51	81.94	Excellent
C	7.69	0.72	2.86	50.01	19.07	80.37	Excellent
D	9.53	1.88	5.84	48.89	18.64	84.80	Good
E	12.81	2.39	7.08	47.97	18.29	88.55	Good
F	17.30	2.09	7.63	45.93	17.52	90.49	Fair
G	18.89	2.65	9.21	48.77	18.60	98.08	Poor
H	38.12	3.13	11.29	49.69	18.95	121.14	Very Poor
I	58.39	4.30	15.45	49.57	18.90	146.58	Very Poor

Flow Chart



VIII. CONCLUSION

From the result table, it is observed that as the TQI decreases, the tea grain quality improves and vice versa. The reverse nature of the TQI with respect to tea quality is due to the fact that the TQI comprises of standard deviations of the grain parameters like diameter, area, perimeter and color. And as the variations in these parameters are observed, the tea quality deteriorates. And standard deviation increases. That is why the TQI bears the inverse relationship with the tea grade quality. The TQI may further be fined tuned by incorporating more parameters in future.

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