Turmeric Grading on Principle Characteristics

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Abstract— India is depending on agriculture and related allied sectors for livelihood. More than 70% of population depend primarily on agriculture. Soil, climate and rainfall are most favourable for various crops. There are few rare and important crops grown in all regions of India in different varieties, one among those crops is Turmeric. Agriculture products marketing has become automated as the result of advanced technologies in Digital Image Processing (DIP) and Computer Vision (CV) techniques. In today's fast, competitive marketing, consumers tend to have healthy and hygienic products that are sorted according to their physical characteristics like appearance, colour, size, moisture content, quality, variety and other physical properties depending on the products. Grading is crucial and important stage after harvesting, storing and before marketing any agricultural products. Turmeric Grading is an overall assessment of quality, based on appearance with respect to colour, shape, texture and size. Curcumin is the colour component in turmeric and obtained by cross sectional image of rhizomes. This paper focuses on grading of Turmeric on curcumin colour by extracting Red Green and Blue (RGB) values using histogram and K-NN classifier. The classification of turmeric rhizomes based on size is done by calculating the area of the rhizome's images. Canny edge detection algorithm is used for edge-based segmentation and area is calculated by pixel count of the image and categorized into three grades.

Keywords: Turmeric, moisture content, Digitization Curcuma Longa L, Computer Vision (CV)

I. INTRODUCTION

Curcumin Longa L, is an ancient important rhizomatous perennial herb that originates from India. It's commonly known as Turmeric or 'Haldi' in *Hindi*. Indian turmeric is considered to be the best in the world. Climatic conditions, rain fall and the soil is most favourable in Turmeric cultivation across India. Most popular varieties of Turmeric grown in India are Allepy in Kerala, Rajmore, Karhadi and Sangli in Maharashtra, Erode and Salem in Tamilnadu, Nizamabad bulbs in Andhra Pradesh, other varieties like Suguna, Roma, in Orissa, Karnataka, West Bengal, Gujarat, Meghalaya and Assam. It's a seven to ten months crop depending upon the variety, usually cultivated during March and harvested in the month of November. It's a golden herb widely used in culinary, condiments, dye, drug and cosmetics. Turmeric is derived from rhizomes, a tuberous, with a rough and segmented skin. Theses rhizomes mature in the ground, beneath the foliage. Post-harvest process of turmeric includes washing, boiling, sun drying, polishing, sorting, grading, packing and finally transportation. Post - harvesting process is a very important and crucial stage where the fresh turmeric rhizomes are steamed or boiled in large boilers to get rid of raw odour, gelatinize the starch and get uniform coloured product. Later they are sun dried immediately for several days to get final moisture content maintained to 8% to 10%. Then the dried rhizomes are polished to get the smooth surface and sorted according to the size. Grading is an important step in turmeric marketing as the product quality is most important aspect. Turmeric trade is done in 3 forms namely *Fingers*: Their size varies from 2.5 cm to 7 cm in length and diameter around 1 cm. These are lateral branches or secondary rhizomes which are detached from the central rhizome before curing. *Bulbs:* These are central 'mother' rhizomes, which are ovate in shape and are of shorter length and having larger diameter than the fingers and *Splits*: Broken bulbs to facilitate curing process followed by drying. Eye observation by experts and agents is the traditional method followed till today in grading of turmeric. Farmers and agents travel often in making consultation of their products which is expensive and time consuming. Inspection includes labour intensive work, decision made thereof can be subjective to the mood and knowledge of people involved. Furthermore, this manual procedure can be very time consuming and inefficient when dealing with high production. The colour and size of turmeric after processing influences the price of the product. This paper helps the rhizome grading on colour and size basis. Colour features are extracted to compute the morphological parameters of the image. The size is determined by the area occupied by the image enclosed within the boundaries. Image processing techniques are introduced to overcome the manual grading which requires hiring an expert to undertake the inspection process. Further it can be extended to grading based on moisture content and other geometrical properties.

II. LITERATURE SURVEY:

Significant number of researchers had worked on Digital Image Processing applications in agriculture products. The main areas included Soil Quality Detection, Plant Disease Detection, Prediction of Yield, classifying different varieties, detecting the defects in fruits and vegetables, Grading and Sorting of final products.

Ms. Rupali S J and Prof S S Patil [1] proposed a method on fruit quality Management using the RGB colour component extraction and an ARM7 microcontroller. They focussed on the fruit's axis and the centre coordinate of the fruit in the image. The diameter of the fruit is calculated by detecting the edges and grading is done on size basis. P. Vimala Devi et al. [2] has studied different techniques for fruit sorting and defect detection using Computer Vision technique. Noise removal techniques in linear filtering, non-linear filtering and adaptive filtering are discussed and the importance of different Noise removal methods in an image processing are discussed and compared. Anuradha Gawande et al. [3] developed the system that recognises the infected region on the fruit images. The infection severity is analysed according to the damage on external surface and partial, full infected regions are detected on single image. Megha P

Arakeri and Lakshmana [4] used the Gray Level Co-occurrence Matrix for evaluating the quality of Tomatoes. They developed the system for fruit handling and Image processing using 8051 microcontrollers along with DC gear motor, UART Bridge and a system camera. Colour and texture statistical feature are extracted to grade the tomatoes. Debasmitha Bhoumik [5] have proposed a method called SURF (Speeded Up Robust Features) and worked on identifying the three fruits namely, Apples, Oranges and Pine apples based on their size, shape, colour and texture. The database is created for classification of these fruits quality as Good, Medium and Bad depending on the surface characteristics. Sakshi Jha et al. [6] have developed a system for grading the tomatoes on size basis. They extracted the individual tomato image from the bunch of images and pre-processed it. They have used the median filter-b and removed the noise. Noise reduction makes the image clearer for analysing and feature extraction. The fruit image is converted into binary and holes are filled. Area is calculated for grading on size basis. The Computer Vision based quality assessment is done on Fruits such as Apples [4], Mango [6]. The Physical properties, Geometrical Properties, Frictional, Gravimetric properties of turmeric are of Turmeric rhizomes [5] are studied and tabulated.

Ms. Anuraradha et al [7] proposed the system using multi grading classification for grading of Apples. The rotten area on the Apple surface is identified and the percentage of affected area is considered to classify them as Healthy, partially affected, Moderately affected or Unhealthy. K. Vijayarekha [8] proposed the system for identifying the defects in Apple fruit. Segmentation of infected area on the image surface is done by using multivariate analysis. They grouped the pixels having the identical Spectral property and a single region is made to identify the external defects on Apple. Unay and Gosselin [9] surveyed on of different Thresholding methods such as Otsu, Isodata and Entropy are compared the performance of each method. Artificial Neural Network (ANN), k-NN, fuzzy k-NN, Linear Discriminant Classifier (LDC), Support Vector Machine (SVM) are used to detect the defects in fruits and supervised classifiers are used to classify them. Yogitha S and Sakthivel P [10] have proposed system for automatic Inspection and Grading of Fruits. They used the distributed Networks architecture through GigE LAN to interface the camera to the system. Colour estimation information and other geometric parameters are extracted to inspect the fruit against defects and grading.

Payman Moallem et al [11] have proposed an algorithm for apple quality assessment. Segmentation is done on fruit images and Statistical features, Textural features and Geometric features are extracted and stored in vector. Classification is done by Support Vector Machine, KNN classifier and Multi-Layer Perceptron (MLP) and they obtained a good accuracy. They have compared all the classification techniques and grading is done in two categories healthy and defected. Gouri Deepak et al [12] have developed automatic grading system for an Apple, the defects are extracted using Gray Level Co-occurrence Matrix (GLCM) and Classification is done by KNN classifier. They have proposed an algorithm and discussed the experimental results. A Nasirahmad et al have developed the algorithm for identifying the bean varieties on colour basis, [13] Gaussian filter is used to remove the noise and Classification is done by Artificial Neural Networks (ANN). A Multi-layer Perceptron was employed for modelling the network. They extracted the twelve colour features for classification. T Riquilme et al have proposed the system for classifying the olive fruit in eight classes. [14] The external damage like colour, and texture are studies against damage. Histogram is plotted on all Gray levels to categorize the fruits. Discriminant Analysis method is used for classification.

III. METHODOLOGY:

A. Image Acquisition:

Turmeric rhizome's images are obtained using Digital Camera with high resolution of 16Mp. The standard distance is maintained about 6 inches between camera and the image while capturing. The images are captured in natural sunlight so as to get significant clarity in colour, brightness and size.

B. Pre-processing and Image Analysis

Pre-processing is a process where input is an image in .bmp, .gif etc. forms and output is an image or character set of images. Digitization of an image followed by Cropping, Resizing, Background removal and Contrast enhancement are carried out at this stage. The Pre-processing helps in maximizing the clarity and sharpness of the image. Image analysis returns the numeric values, decision and/or graphical information about the image characteristics that is suited for classification, defect detection, prediction of diseases and measuring the quality parameters of the image.

C. De-Noising:

The process of removing the noise i.e., unwanted inferences in the image is De-noising. Environmental factors that contribute to the noise are humidity, temperature and light conditions. Non-ideal or poor image sensors, interference of signals during transmission in wireless network complements noise to the image. Linear filters are used to remove the noise.

D. Cross Conversion:

The images after background and noise removal are considered for cross-conversion. RGB images are converted into grey images and then into binary for edge detection. Canny edge detection method is selected as it is found suitable in extracting the boundaries, edges and the inner objects of the image for grading. Area is estimated by total number of pixels between the image boundaries. This gives the size of the rhizome for Comparison.

E. Feature Extraction and Determine Region of Interest (RoI):

The Colour and the Edge features are extracted by plotting the Histogram and Canny edge detection algorithm respectively. The Cross-section of the image is taken, centre part of 30X30 dimensions is cropped and is selected as the RoI in proposed methodology to find the deepness of the turmeric colour or curcumin content of the rhizome.

F. Database:

The database is a record of all extracted morphological characteristics of input image such as Mean, Median,

Standard Deviation and RGB colour values. The standard database contains all Physical, Morphological values that are obtained from the Agriculture University.

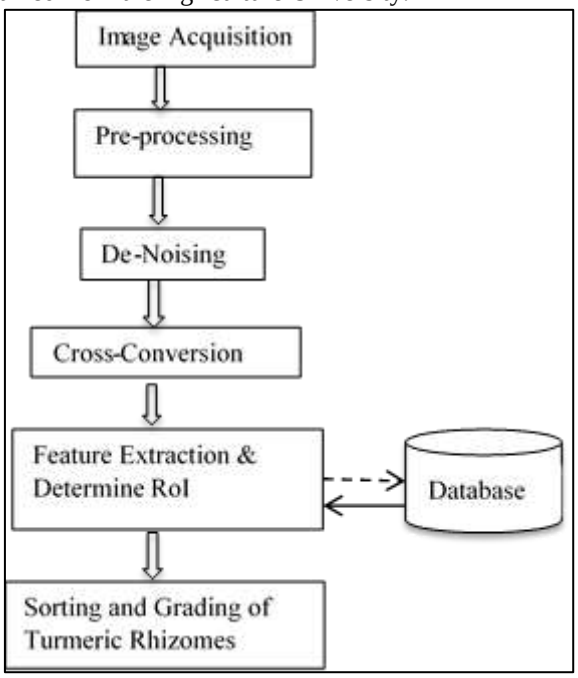


Fig. 1: Flow Diagram

G. Sorting and Grading of Turmeric Rhizomes:

Sorting of Turmeric rhizomes are done with the classifier that compares both principal components: Size and Colour. Grading is done on all geometric properties such as length, breadth thickness, mean-diameters etc. k-NN Classifier is used for classification. This paper concentrates on grading of rhizomes on only two aspects, Colour and Size. 100 sample images are considered for the training phase. Some of the Turmeric varieties and their Sizes and the colours are used for the study. The following table shows the five varieties considered for study and their parameters and colour.

1) Grading Based on Colour:

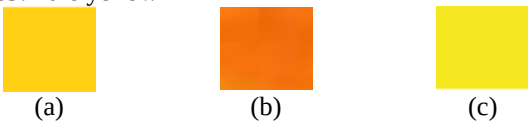
Non-Destructive methods are favourable for agriculture products. In the proposed methodology, we have collected 100 sample images from Sangli variety of healthy turmeric rhizomes after post harvesting process. In the cross

Turmeric is mainly available in mainly 3grades in commercial market.

Grade1: Reddish Orange

Grade2: Bright yellow

Grade3: Pale yellow



(a) (b) (c)

Fig. 2: Images of Curcumin Colour used for grading (a) Pale yellow (b) Bright yellow (c) Reddish Orange

Variety of turmeric	Grade	Length in mm	Width in mm	Thickness in mm	Colour
Salem	I	69.9	44.3	4.7	Orange
	II	54.9	35.6	5.2	
	III	45.2	36.2	4.3	
Sangli	I	53.8	35.47	6.2	Saffron
	II	46.91	27.13	4.6	
	III	36.9	29.22	3.0	
Krishna	I	66.30	46.41	5.6	Yellow
	II	54.84	40.52	5.1	
	III	48.45	35.74	4.5	
Wardha	I	62.41	38.29	5.3	Bright Yellow
	II	54.99	36.80	4.8	
	III	41.66	32.43	2.5	
Rajmore	I	56.46	35.62	6.1	Yellow Orange
	II	48.46	32.24	5.8	
	III	39.46	29.46	5.6	

Table 1: References used for classification on size and colour basis of different varieties of turmeric rhizomes

2) Algorithm 1: Colour Feature Extraction

Input: RGB colour image of RoI of turmeric rhizome
Output: Colour histogram
Start:
Step 1: Read the input image from the Dataset
Step 2: Convert it in RGB colour space.
Step 3: Extract the colour features Red (R), Green (G) and Blue (B) components.
Step 4: Use RGB bins and obtain the histogram.
Step 5: Apply k-NN Classifier for Grading
End

In RGB, the colour is formed by overlapping the Red, Green and Blue channels.

Yellow = Red + Green

Considering the decimal representation

Yellow is (110) and white is (111)

Intensity of yellow colour= 1- tristimulus of Blue

Fig. 3: Sample Images of Cross section of Rhizomes and RoI

3) Grading Based on Size:

The size of the turmeric rhizomes is estimated by the area occupied by the standard image. The area calculation is done as the total number of pixels within the boundaries of the standard input image. Signal to Noise Ratio (SNR) is high in Canny algorithm thus making it to accurately mark edges and boundaries. [11] The average physical dimension of turmeric for three grades as

Grade1: length (L) =30.08mm, breadth (B) =10.64mm and thickness (H) =6.44mm

Grade 2: length (L) =40.57mm, breadth (B) =9.72mm and thickness (H) =5.47mm

Grade 3: length (L) =50.60mm, breadth (B) =9.94mm and thickness (H) =5.18mm

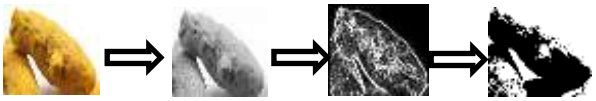
The Area is calculated by formula

Area= 2*(L*B+B*H+H*L) ---------- (1)

4) Algorithm 2:

Input: Data set of RGB colour image of turmeric rhizome
Output: Grading of turmeric rhizomes as Grade1, Grade2, and Grade3
Step 1: Read the RGB images turmeric rhizomes.
Step 2: Convert the image into Gray image
Step 2: Apply the edge detection algorithm
Step 3: Convert into Binary image

Step 6: Compute Area Using formula (1) in the form of non-zero elements of the Binary image
Step 7: Compare input image and training dataset to Classify as
If the Area >=15000 pixels classify as Grade1
Else if Area>=1000 pixels classify as Grade2
Else Grade3



(a) (b) (c) (d)

Fig. 3: Sample Images (a) Original RGB Image (b) Gray Image (c) Edge Detection (d) Binary Image

Experimental Results: Accuracy of the proposed methodology is calculated by the formula (2). The results of grading based on colour and size is as shown in the Table (2) and (3) respectively.

$$\text{Accuracy} = \frac{\text{Correctly graded rhizomes}}{\text{Total number of test samples}} \quad \text{--- (2)}$$

Number of samples	Test samples	Grade1	Grade2	Grade3	Accuracy obtained in %
100	56	28	13	15	78

Table 2: Result of grading on colour basis

Turmeric grade	Training phase samples	Testing phase samples	Accuracy obtained in %
Grade1	100	27	70
Grade2	100	24	81
Negative	100	26	68

Table 3: Result of grading on size basis

IV. CONCLUSION:

The grading of turmeric is done on the basis of colour and size components. Colour feature is extracted at the RoI i.e curcumin colour in the turmeric image and analysed using Colour Histogram method. The deepness of colour is identified and Classification by K-NN Classifier. To grade the turmeric rhizomes on size basis Canny Edge Detection algorithm is used and area enclosed between the edges is calculated for comparison and Classification. The results are good as compared with the traditional method. This method is convenient, non –destructive, fast and accurate with the average accuracy of 80%. Further the grading can be done based on physical properties of turmeric such as weight, number of bulbs to the rhizomes etc.

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