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Maturity Detection of Fruits and Vegetables using K-Means Clustering Technique

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Abstract: *The aim of this paper is to present a novel method for determining the maturity detection of fruits and vegetables and also to classify the degree of ripening by using k-means clustering algorithms and fuzzy based classification technique. Sample data is trained for four different kinds of maturity: fully ripe, partially ripe, immature and rotten. The images of the fruits and vegetables are acquired using a digital camera and after applying image processing techniques, the RGB values of the vegetables were processed by kmeans algorithm using MATLAB software. Linear discriminate analysis is then used to transform the feature space after feature fusion for better separability. This approach of having low cost, non destructive method of maturity detection would be very helpful for fruit or vegetable farmhouses and to automatically identify the maturity of the fruits or vegetables.*

1 INTRODUCTION

In olden days, the people working in farmhouses used to identify the ripening of fruits and vegetables using their natural vision, which would have been subjected to high rate of errors because of illness, distraction and other factors during working hours. This also may affect the working speed of system. There are various methods to detect the ripeness of fruits and vegetables. Artificial vision techniques provide reliability, high speed and repeatable operation. Hence the production increases and reduces its dependency on manpower. In machine vision system computer uses different method to analyze the given image of fruit and vegetable. Previously, computer systems were not robust enough to operate on large and real colours of images, so mostly gray scale images had been the main focus for researchers. But today, computer system has been developed enough to work on large and true colour images. [5]

With increased expectations for food products of high quality, the need for accurate, fast and objective quality determination in food products became necessary. External quality is considered of paramount importance in the marketing and sale of fruits. The appearance i.e., size, shape, colour and presence of blemishes and quality of fruits influences consumer perceptions and therefore determines the level of acceptability prior to purchase. The existing colour grading systems use a set of colour separating parameters to determine the colour quality. With the use of these methods, it is not convenient to adjust colour preferences or grading parameters for the user in. So, an effective and user-friendly colour mapping concept for automated colour grading of fruits that is well suited for commercial production. A general approach is developed to estimate the ripeness level without touching the fruit.[1]

2. SINGLE FRUIT MATURITY DETECTION

2.1 ALGORITHM

Step1: Input RGB coloured image

Step2: Apply color image segmentation

Step3: Calculate mean value of red, green and blue layer

Step4: Fuzzy Logic classification is applied to classify whether fruit is ripe, under ripe or over ripe.

2.2FUZZY LOGIC

The fuzzy set is the set without a crisp, clearly defined boundary. It can contain elements with only a partial degree of membership. A fuzzy set is defined by the following expression:

$S = \{(x,\mu S\ (x)|x\in X\ )\}$ (1)

where $\mu S\ (x)\ \in([0,1])$ is the membership function (*MF*) of fuzzy set S,

X is the universal set, x is an element in X,

S is a fuzzy subset in X.

Degree of membership for any set ranges from 0 to 1 where value of 1 represents 100% membership and 0 means 0% membership. A MF is a curve that defines how each point in the input space is mapped to a membership value between 0 and 1. The input space is sometimes referred to as the universe of discourse. The *MFs* are usually defined for inputs and output in terms of linguistic variables. There are many forms of *MFs* such as triangular, trapezoidal, Gaussian etc. In this study, triangular MFs were selected for input and output variables as they can represent our linguistic variables more effectively

The triangular MF is a function that depends on three scalar parameters a, b and m shown

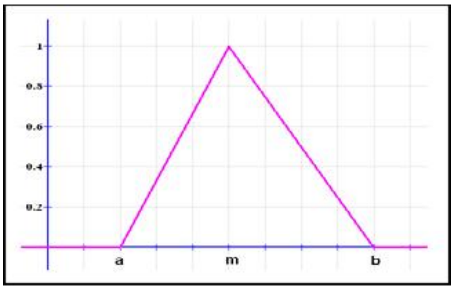

Fig. 1. Triangular Membership function

Triangular function: defined by a lower limit **a**, an upper limit **b**, and a value **m**, where **a** < **m** < **b**.

$$\mu a(x)=\begin{cases} 0 & x \le a \\ \frac{x-a}{m-a} & a \le x \le m \\ \frac{b-x}{b-m} & m \le x \le b \end{cases} \quad (2)$$

Fuzzy sets and fuzzy operators are the subjects and verbs of fuzzy logic. The *If-Then* rule statements are used to formulate the conditional statements that comprise fuzzy logic. The fuzzy If-THEN rule is presented in the following form: *IF x* is A *THEN y* is B where A and B are linguistic values defined by fuzzy sets on the ranges X and Y, respectively. The *If-Then* part of the rule "X is A" is called the antecedent or premise, while the then-part of the rule

"Y is B" is called the consequent or conclusion.More generally, rules have more than one premise, that is:

Ri : IF xi is Ai AND *yi* is Bi THEN *z i* is Ci where *i* = 1, 2, n (n is the number of the rules). Ai ,Bi and Ci are the fuzzy sets for the inputs (*xi & yi*) and the output *i z* , respectively in the i-th rule, Ri. The values of Ci are the linguistic terms such as Unripe, Ripe, Over ripe.

For mango ripeness evaluation, three attributes such as Red, Green and Blue intensity colour were used in the IF-part or antecedent of the rules.

2.3 DATA ACQUISITION

2.3.1 INPUT RGB COLOURED IMAGE

Each colour is made up of combination of three primary colours- red, green and blue. To represent a colour in colour image each pixel has a fixed value of red, green and blue components. In RGB colour space pixel p(i) is defined by ordered triplet of red, green and blue coordinates (r(i),g(i),b(i)),which represents the intensities of red , green and blue light respectively. The intensity value varies from 0 to 255. According to, it is an M*N*3 array of pixels, where each colour pixel is a triplet corresponding to the red, green and blue components of an RGB image at a specific spatial location.

2.3.2 NORMALIZATION

To classify the fruit into under ripe, ripe and overripe categories, obtain a range of mean value of red, green and blue layer for each fruit. These ranges values are used as a reference and a range input of fuzzy logic system. A total of 80 images are used in determining the range value of red, green and blue of each category. The mean values of red, green and blue layers are calculated using the following equations:

Mean R = R / No. of pixels

Mean G = G / No. of pixels

Mean B = B / No. of pixels

Where Mean R = Mean value of Red layer

Mean G = Mean value of Green layer

Mean B = Mean value of Blue layer

R = Red pixel

G = Green pixel

B = Blue pixel

This step is individually performed on each images. The range value i.e minimum and maximum of RGB value for each category (under ripe, ripe and over ripe) is obtained from the above calculation.

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This range value is used as a reference for the fuzzy logic system in order to classify the category of apple.

First, the colour matching rate is calculated by $X=\frac{y}{9}\times100\%$ (3)

where X is a colour matching rate,

y is a current colour value,

999 is reference colour value.

Next, the mean value of each sample is calculated using ,

$$M(x)=\frac{\sum_i^n x}{N} \quad (4)$$

where $M\ (x)$ = mean value of R,G and B for each category.

$\sum_i^n x$ = sum of R,G and B and N is total number of R,G and B.

Then, the data is normalized by using as below:

$$F(x)=\frac{C(x)-M\ \ (x)}{M\ \ (x)-M\ \ (x)}\times 100 \quad (5)$$

where $F\ (x\ )$ is normalized colour value in R, G and B. $C\ (x\ )$ is a current colour value of R, G and B.

$Min\ (x)$is a minimum colour value and

$Max(x)$ is a maximum colour value is taken from the lowest and highest R, G and B colour value.

Category	Red	Green	Blue
	Min max	Min Max	Min Max
Unripe	0 35.35	57.39 79.97	33.52 49.65
Ripe	34.77 51.63	33.61 51.03	20.8 29.75
Overripe	66.97 81.54	0 35.30	0 13.56

Table. 1. Range of RGB Used for Unripe, Riped and Over Riped Tomatoes

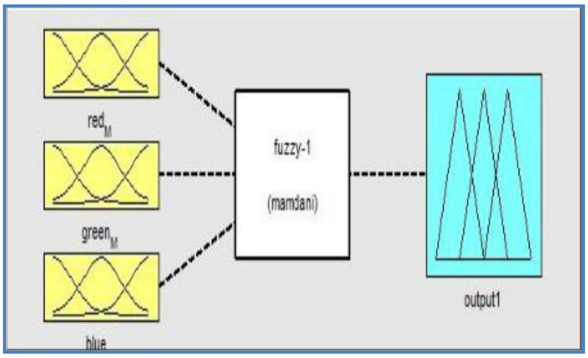

Fig. 2. FIS editor 1 consist of three inputs and one output

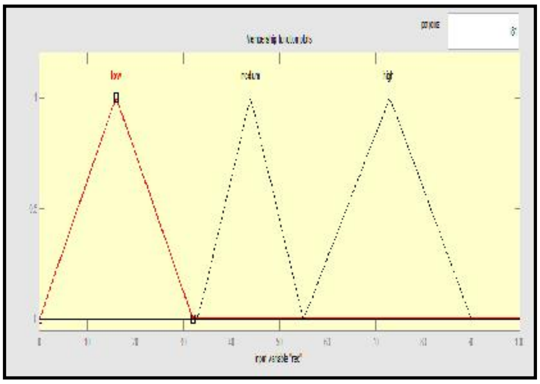

Fig.3.Membership function representation of red input

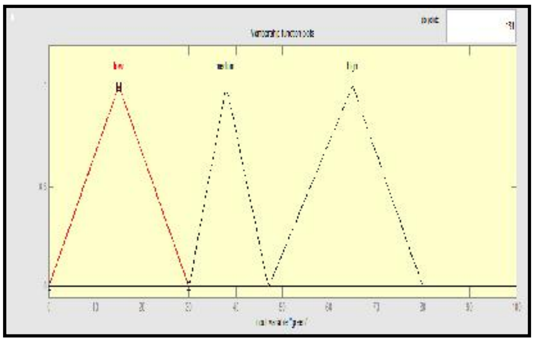

Fig.4. Membership function representation of green input

The three inputs are mean values of Red, Green and Blue layers and output1 is Category (ripe, under ripe, about to under ripe, about to overripe and overripe). The membership functions are builds using trapezoidal shapes since it gives the best result compared to other shapes. A total of 40 rules statements are created in order to classify the apple categories. The rules are illustrated as follows

RED	GREEEN	BLUE	CATEGORY
LOW	HIGH	MEDIUM	UNRIPE
MEDIUM	MEDIUM	MEDIUM	RIPE
HIGH	LOW	LOW	OVER RIPE
LOW	HIGH	HIGH	UNRIPE
MEDIUM	LOW	MEDIUM	RIPE
HIGH	LOW	MEDIUM	OVER RIPE
MEDIUM	HIGH	LOW	UNRIPE
HIGH	MEDIUM	LOW	OVER RIPE
MEDIUM	MEDIUM	LOW	RIPE
MEDIUM	HIGH	HIGH	UNRIPE
MEDIUM	MEDIUM	HIGH	RIPE
MEDIUM	LOW	LOW	OVER RIPE

Table .2. If then rules

Based on the defuzzification result from the Rule Viewer from Fig. 7, the apple fulfilled Rule 1 where red is low, green is low and blue is low. The value of the category is calculated by using the centroid method. The defuzzification rules are:

1.If the defuzzification output lies between 0 to 30, Category is under ripe .

2.If the defuzzification output lies between 15 to55, Category is about to ripe.

3.If the defuzzification output lies between 50 to 90, Category is overripe.

2.4 CLASSIFICATION OF TOMATO

Tomatoes are classified into 4 categories depending upon the maturity level hence they are ripe, fully ripe, partially ripe, and unripe.


Fig.5. Fully ripe **Fig.6.** Overripe

Mangoes and tomatoes which are free fromm abnormal features such as defects are selected

for this experiment. The fruits should be varied in their surface colour and maturity level.


Fig.7. Partially riped **Fig.8**. Unripe

The images are acquired using a RGB colour sensor in terms of red, green and blue colours. The area of measurement around the stalk of the fruits give more accurate information about fruit ripeness . Before measurement, pure colour of red, green and blue are sensed as reference colour. The colour matching rate is calculated from measured data and mean value . The second step, all developed data in each category for each Red, Green and Blue are combined and normalized. To develop membership function of input variable and output category, the range of red, green and blue are determined for each category. Eighty fruits in which twenty for each category are used to calculate the value of range colour. These range value are used as reference and range input of fuzzy set.

3. MULTI FRUIT MATURITY IDENTIFICATION USING K MEANS CLUSTERING

Image segmentation is a process that groups together pixels that have similar attributes. Segmentation process splits an image into various regions, and provides all the relevant data required for analyzing and grading of a digital image. Finally it separate out the unwanted background from the digital image and shows the object of interest. Image segmentation process is a crucial stage in the image analysis where the results in this stage persuade the concert of the entire process. Segmenting the selected region guarantees that only the object of interest was processed during the analysis phase. However, the segmentation process has happen to be a challenging issue because of the complex background and changeable illumination on the images. Therefore it is significant to have an efficient segmentation technique that will be able to divide an image into foreground and background,

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accurately and effectively in presence of natural illumination. Image segmentation has become an important step to analyze the various objects in automated manner [4]. It provides vast application in the field of agriculture, industries, medical, and in recognition tasks. Image segmentation is most useful in agriculture specifically in detecting the infected fruit part , in classifying the fruits , in fruit quality management , for on plant fruit detection and for estimating the crop also segmentation is used in fruit maturity recognition**.**

3.1 CLUSTERING ALGORITHMS

Clustering means to create groups of same elements whereas algorithm means a step by step procedure for calculation. Hence clustering algorithms are the step by step procedure to calculate clusters of similar colour pattern in image. In [1], there are many partitional clustering algorithms that are used for colour image segmentation like K- means, the Fuzzy c means, the Gustafson Kessel improved by Babuska(GK-B) and the Gustafson Kessel Possobilistic Fuzzy c Means(GKPFCM). The performance of these algorithms depends upon the amount or type of information and the distance measure it uses. In this case, distance is the squared or absolute difference between a pixel and cluster centre but the result can be improved if spatial information is also taken into account. This will improve the better identification and quantification of the objects in the partitioned region of image.

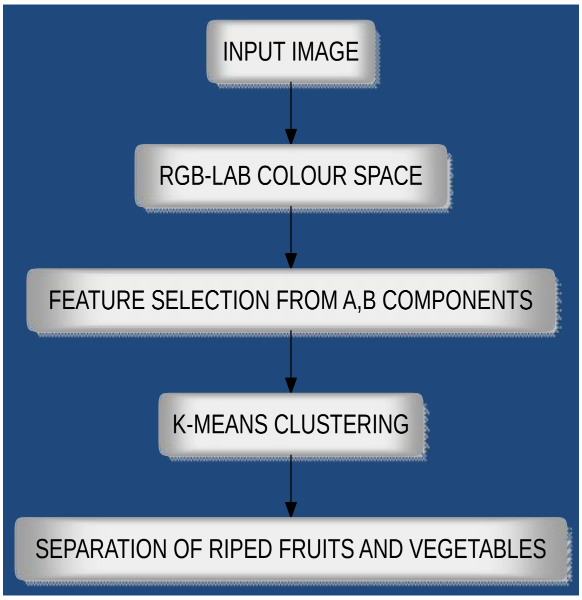

Fig. 9. K-means Algorithm

Fig.10. Input image 1

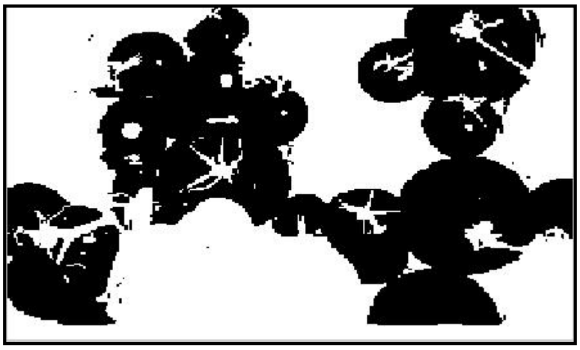

Fig.11. Image labeled by cluster index

Fig.12. Objects in cluster 1

Fig.13

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. Objects in cluster 2

Fig.14. Input image 2

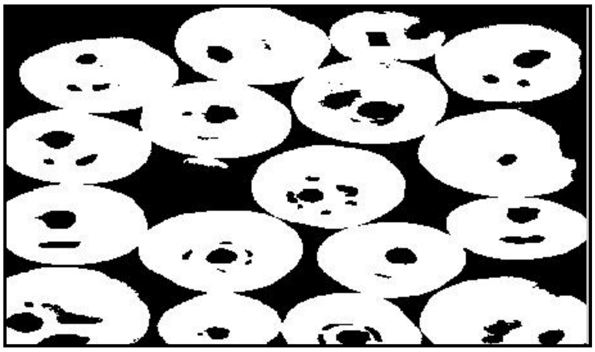

Fig.15. Image labeled by cluster index

Fig.16. Objects in cluster1

Fig.17. Objects in cluster2

Fig.18. Input image 3

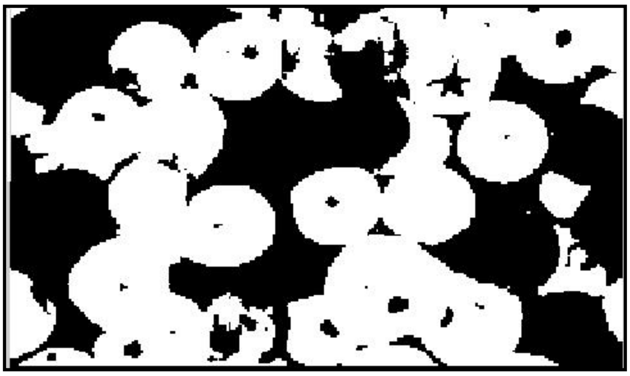

Fig.19. Image labeled by cluster index

Fig.20. Objects in cluster 1

Fig.21. Objects in cluster 2

3.3 CONCLUSION

In this paper fruit image segmentation is carried out using Grayscale segmentation and K-means adaptive and black and white segmentation. Various segmentation approaches are developed which were able to segment the circular fruit images like orange, lemon etc, but these developed methods were not that accurate to segment irregular shape fruit. In case of segmentation of irregular shape images the main problem took place when those images are captured under natural illumination. Natural illumination tempt unequal amount of light intensity on the surface of the fruits, which results in low quality image segmentation. Hence k means method is developed which is able to segment the different shape fruit images captured under natural illumination more accurately.

SCOPE FOR FUTURE WORK

Each segmentation method and its approach for segmentation are restricted for a particular fruit only along with the provision for illumination. Some of the improved and hybrid approaches had overcome the illumination effect but effort must be taken to develop an approach which would be able to segment the images of various irregular shape fruit in natural illumination accurately.

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