Crop Growth Prediction Based On Fruit Recognition Using Machine Vision

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Abstract— **one of the major required growths is for the fruit harvesting system is the efficient locating the fruit on the tree. In this work it is proposed that crop is predicted based on number of fruits grown on crop or plant. Hence already grown plant with fruits is considered for database. The plant images of apple, sapodilla, orange, mango, and guava are considered. The fruit region is located and segmented using edge detection and circular fitting algorithm. For the segmented region morphological operations are adapted to get proper boundary. The colour and shape features are extracted for the fruit region. The plant images are trained by fuzzy logic classifier. The recognition accuracy of 90% is observed. After this label count is applied to get an approximate fruit count. In the proposed work it is observed that crop growth can be predicted based on fruit count with a threshold 2. The accuracy of this prediction is 78%. Here to small, blobs and similar colour accuracy is less. Hence, we have carried out work for predicting the crop growth based on fruit. An automatic system is developed.**

Keywords— **Colour space, feature extraction, fruit recognition, fruits, fuzzy logic, segmentation.**

I. INTRODUCTION

A crop is a volunteered or cultivated plant whose product is harvested by a human at some point of its growth stage. Crops refer to plants of same kind that are grown on a large scale for food, clothing, and other human uses. They are non-animal species or varieties grown to be harvested as food, livestock fodder, and fuel or for any other economic purpose (for example, for use as dyes, medicinal, and cosmetic use). Plants which have not been cultivated but whose product are harvested, are not really classified as crops. The same goes for plants which have been planted, but are never harvested. Flowers are classified as crops because when it has been cultivated, its harvesting also includes the aesthetic purpose it serves. Crop production is concerned with the exploitation of plant morphological (or structural) and plant physiological (or functional) responses with a soil & atmospheric environment to produce a high yield per unit area of land. Growth is irreversible increase in size or weight.

Crop production provides the food for human beings, fodder for animals and fiber for cloths. Land is the natural resource which is unchanged & the burden of the population is tremendously increasing, thereby decrease the area per capita. Therefore it is necessary to increase the production per unit area on available land.

Economic growth is the increase in the amount of the goods and services produced by an economy over time. It is conventionally measured as the percent rate of increase in real gross domestic product, or real GDP. Growth is usually calculated in real terms – i.e., inflation-adjusted terms – to eliminate the distorting effect of inflation on the price of goods produced. In economics, "economic growth" or "economic growth theory" typically refers to growth of potential output, i.e., production at "full employment".

Horticulture is the science, technology, and business involved in intensive plant cultivation for human use. It is practiced from the individual level in a garden up to the activities of a multinational corporation. It is very diverse in its activities, incorporating plants for food (fruits, vegetables, mushrooms, culinary herbs) and non-food crops (flowers, trees and shrubs, turf-grass, hops, medicinal herbs). This range of food, medicinal, environmental, and social products and services are all fundamental to developing and maintaining human health and well-being. Horticulturists apply the knowledge, skills, and technologies used to grow intensively produced plants for human food and non-food uses and for personal or social needs. Their work involves plant propagation and cultivation with the aim of improving plant growth, yields, quality, nutritional value, and resistance to insects, diseases, and environmental stresses.

Machine vision offers the best potential to automatically extract, identify, and count target plants, based on colour, shape, and textural features. However, directing the image analysis process toward the classical botanical taxonomic, plant identification approach has previously required considerable supervised human intervention. A major problem is the presentation of plant features including individual fruits to a discrimination or classification system.

II. RELATED WORK

To study the state of art the related work in the field and problem are outlined.

Woo Chaw Seng [3] presented a new Fruit recognition system has been proposed, which combines three features analysis methods: colour-based, shape based and size-based in order to increase accuracy of recognition. For Fruits Recognition System, the KNN algorithm performs fruit classification by using the distance measure system shows the fruit name and a short description to user. Proposed fruit recognition system analyzes, classifies and identifies fruits successfully up to 90% accuracy.

Dr. M.V.Joshi [4] has worked on efficient locating the fruit on the tree is one of the major requirements for the fruit harvesting system. To detect the fruit, an image processing algorithm is trained for efficient feature extraction. Extraction of intensity and colour features, extraction of orientation features, extraction of edge features, extraction of fruit region. This section detection results and analysis of the proposed fruit region detection approach. Efficient fruit detection using multiple feature based algorithm is developed and proposed in this paper. Multiple features like intensity, colour, edge and orientation are analyzed.

H N Patel, A D.Patel [9] has worked on efficient locating the fruit on the tree is one of the major requirements for the fruit harvesting system. Colour and shape analysis was utilized to segment the images of different fruits are obtained under different lighting conditions. The pre-processing of the input image was performed first, Segmentation of a fruit image, Binary noise-removed image was labelled to extract the fruits, Fit the Circle to the edge points. The results indicate that the proposed method can accurately segment the occluded fruits with the efficiency of 98%.

M.A.Vazquez-Cruz [14] has worked for a review of mathematical modelling applied to fruit quality showed that these models ranged in resolution from simple yield equations to complex representations of processes as respiration, photosynthesis and assimilation of nutrients. The latter models take into account complex genotype environment interactions to estimate their effects on growth and yield. Models are used to estimate seasonal changes in quality traits as fruit size, dry matter, water content and the concentration of sugars and acids, which are very important for flavour and aroma.

Varun Gupta [21] has implemented on Image segmentation plays an important role in human vision, computer vision, and pattern recognition fields. Segmentation based on texture can improve the accuracy of interpretation. Satellite images are used in order to detect the distribution of classes such as soil, roads, rivers, lakes etc. A problem that arises when segmenting an image is that the number of feature variables or dimensionality is often quite large.

III. PROPOSED METHODOLOGY

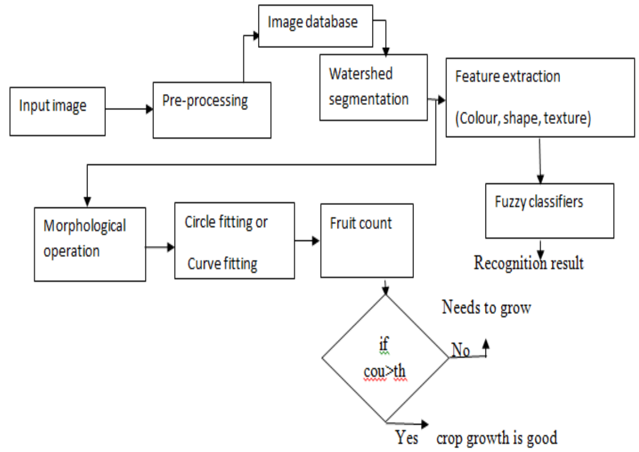

Figure 1. Proposed architecture

Image acquisition

The crop images are captured from a digital camera. The image includes fruits in a crop. The crop image has number of fruits in a tree. Images are taken from a field.

Figure 2. Mango image

Image segmentation

The first step in image analysis is to segment the image. Segmentation subdivides an image into constituent parts or object. Segmentation of a fruit image in four regions, they are leaves, fruit, branches and background was found to be more successful then segmenting in two or three regions. The segmentation process should stop when the object of interest have been isolated. The watershed segmentation is attractive it's because it produces closed well defined region, behaves in a global fashion and provides a frame work in which a priori knowledge about the images in particular application can be utilized to improve segmentation result. Segmentation using watershed transform it will apply to grey scale image processing in a way that can be used to solve a variety of image segmentation. Segmentation using distance transform is the distance from every pixel to the nearest non zero valued pixel.

Figure 3. Before and after segmentation

In this work for the segmented image, sobel operation is adopted. The sobel operator is used in image processing, particularly within edge detection algorithms. At each point in the image, the result of the sobel operator is either the corresponding gradient vector or the norm of this vector. The sobel operator is based on convolving the image with a small, separable, and integer valued filter in horizontal and vertical direction.

Circle fitting

The edge points for each labelled region were used as boundary points of each fruit. To fit a circle to scattered data (,) by orthogonal least squares one minimizes the sum of squares

F= (1)

Where d_i is the geometric distance from the data point (x_i, y_i) to the hypothetical circle. The canonical equation of a circle is

$$(x-a)^2+(y-b)^2 = R^2 \quad (2)$$

Where a and b are the centre co-ordinate of a circle and R is the radius of it; then the signed distance is given by

$d_i =$ – R (3)

Note that $d_i > 0$ for points outside the circle and $d_i < 0$ inside it. Hence

$$F(a, b, R) = \sum_{i=1}^{n} [\sqrt{(x_i-a)^2+(y_i-b)^2} - R]^2 \quad (4)$$

An algorithm to fit a circle into scattered pixel data.

1. Find the co-ordinates of the edge pixels.
2. Calculate the mean of pixels.
3. Find the center of the clusters using the mean computed.
4. Compute the coefficients of the characteristics polynomial: 2 + 2 + + + .

For the segmented image colour, shape, texture features are extracted.

Feature extraction

Colour feature

Colour captures a salient aspect of the appearance of produce, and is not dependent on the position or orientation of the produce. The Hue Saturation Intensity (HSI) space. Our system builds its colour histograms in the three-dimensional HSI space. Hue is the spectral shade, which varies continuously from red through green to blue, saturation is the "depth" or "strength" of the colour, and intensity is the brightness or grey level. We convert the camera output to HSI, using the standard transform. The histograms for each of H, S and I dimensions are computed as separate, one-dimensional histograms. Then they are concatenated into one long, one-dimensional, "extended" histogram.

In image processing stage converted RGB colour mode of an original captured image to intensity hue saturation colour mode the HSI colour values are obtained from RGB values by following equation...

I= ((R+G+B))/3 (5)

S=1- 3/(R+G+B) [min(R, G, B)] (6)

W = $\cos^{-1}\{ \; \}$ (7)

H = W if B ≤ G

H = 2π- W if B ≥ G

Referring to all above equations (5)–(6), the values of I, S and H are all depending on the values of R, G and B. Meanwhile, (6) is not depending on (5) and (7) is also not depending on (6). The colour images are recognized by quantifying the distribution of colour throughout the image, change in the colour with reference to average/ mean and difference between the highest and the lowest colour values. This quantification is obtained by computing mean, variance and range for a given colour image. Since these features represent global characteristics for an image, we have adopted mean, variance and range colour features in this work. The equations (5) and (7) are used to evaluate mean, variance and range of the image samples.

$$\text{Mean } \mu = \sum_x x \sum_y P(x, y) \quad (8)$$

$$\sum_{x,y} (x-\mu)^2 P(x, y) \quad (9)$$

Shape feature

Primary investigation based on longitudinal and latitudinal cross section shapes indicated that different shapes were detectable and separable in samples. The different fruit shapes are short, medium, tall and round.

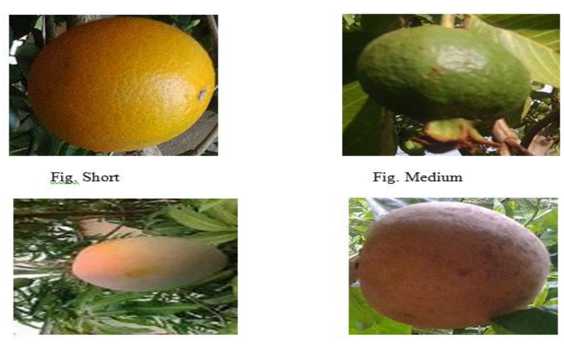

Figure. 4. Different shapes of fruits in a plant.

Since majority of fruits are definite shape and size. Most of the fruits are circular in nature. In this work we considered only plant image with circular shape fruits. In order to recognize and analyze geometrical shapes of a fruits. The circular shape of fruits has the following features. Different shape features are used in work is as follows.

Shape feature	Definition
Aspect ratio	$\frac{\text{Length of major axis}}{\text{Length of minor axis}}$
Compactness	$\frac{100 * \text{area}}{\text{perimeter}^2}$
Elongation	$\frac{\text{Length of major axis} - \text{Length of minor axis}}{\text{Length of major axis} + \text{Length of minor axis}}$
Perimeter To Broadness (PTB)	$\frac{\text{perimeter}}{2(\text{Length of major axis} + \text{Length of minor axis})}$
Length To Perimeter (LTP)	$\frac{\text{Length}}{\text{Perimeter}}$
Length To Width (LTW)	$\frac{\text{Length}}{\text{Width}}$
Cube Of Perimeter To Area By Length	$\frac{\text{Perimeter}^2}{100 * \text{area} * \text{Length of major axis}}$

Texture feature

Texture is a visual feature that is much more difficult to describe and to capture computationally than colour also; it is a feature that cannot be attributed to a single pixel, but rather to a patch of an image. It is a description of the spatial brightness variation in that patch. Texture can be a repetitive pattern of a common unit.

In this paper uses Gray Level Co-occurrence Matrices (GLCM) for measuring the seed surface texture. The GLCM in this research applies five texture features are energy, entropy, contrast, homogeneity, and correlation. Each texture features calculated based on Equations (10) – (14).

Where

P i,j = entry in a normalized gray-tone spatial-dependence matrix.

N = number of distinct gray levels in the quantized image.

a. Energy texture feature

The energy texture is the sum of squared elements in the GLCM. The energy texture also known as uniformity or the angular second moment. The energy can be calculated by Equation 10.

$$\mu_i = \sum_{i,j=0}^{N-1} iP_{i,j}, \mu_j = \sum_{i,j=0}^{N-1} jP_{i,j} \qquad (10)$$

b. Entropy texture feature

The entropy is a statistical measure of randomness that can be used to characterize the texture of the input image. The entropy can be found by Equation 11.

$$\sum_{i,j=0}^{N-1} P_{i,j}(-\ln P_{i,j}) \qquad (11)$$

c. Contrast texture feature

The contrast texture measures the local variations in the GLCM. The contrast texture can be calculated by Equation 12.

$$\sum_{i,j=0}^{N-1} P_{i,j}(i-j)^2 \qquad (12)$$

d. Homogeneity texture feature

The homogeneity measures the closeness of the distribution of elements in the GLCM to the GLCM diagonal. The homogeneity can be calculated by Equation 13.

$$\sum_{i,j=0}^{N-1} \frac{P_{i,j}}{1+(i-j)^2} \qquad (13)$$

e. Correlation texture feature

The correlation texture feature measures the linear dependency of grey levels on those of neighbouring pixels. The correlation is calculated by Equation 14.

$$\sum_{i,j=0}^{N-1} P_{i,j}\left(\frac{(i-\mu_i)(j-\mu_j)}{\sigma_i \sigma_j}\right) \qquad (14)$$

Where

μ_x, μ_y, σ_x and σ_y = the means and standard deviations of p_x and p_y.

The extracted features are trained by fuzzy classifier.

Classification

A classifier is an algorithm that assigns a class label to an object, based on object description. It is also said that the classifier predicts the class label. The object description comes in the form of a vector containing the values of the features deemed to be relevant for the classification task. The classifier learns to predict class label using a training algorithm and a training data. When a training data set is not available, a classifier can be designed from prior knowledge. Once trained, the classifier is ready for unseen objects.

Fuzzy classification is the process of grouping elements into a fuzzy set whose membership function is defined by the truth value of a fuzzy propositional function. Fuzzy classification is the process of grouping individuals having the same characteristics into a fuzzy set. The fuzzy inference diagram is the composite of all the smaller diagrams we've been looking at so far in this section. It simultaneously displays all parts of the fuzzy inference process we've examined. Information flows through the fuzzy inference diagram as shown below.

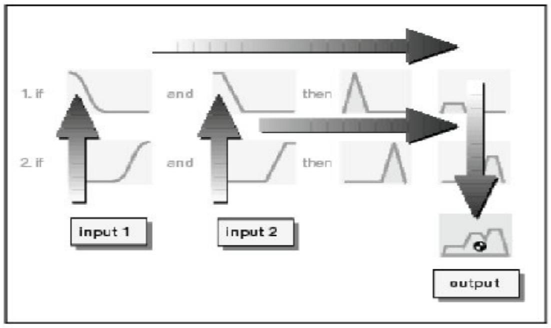

Figure 5. Fuzzy inference diagram

Notice how the flow proceeds up from the inputs in the lower left, then across each row, or rule, and then down the rule outputs to finish in the lower right.

A fuzzy set is a set containing elements that have varying degree of membership in the set. It is contrast with classical or crisp sets, because member of crisp set would not be member unless their membership was full or complete in the set. The membership function is a graphical representation of the magnitude of participation of each input. It associates a weighting with each of the inputs that are processed, define functional overlap between inputs, and ultimately determines an output response. The rules use the input membership values as weighting factors to determine their influence on the fuzzy output sets of the final output conclusion.

In this project we use parameter for classification are image, segmented image, triangular and rectangle waveforms such waveforms as shown in fig 5. A fuzzy system is an alternative to traditional notions of set membership and logic that has its origins in ancient Greek philosophy.

Fuzzy Logic has emerged as a profitable tool for the controlling and steering of systems and complex industrial processes, as well as for household and entertainment electronics, as well as for other expert systems and applications like the classification of SAR data.

IV. Results And Analysis

Figure 6. GUI for selecting database

The figure 6 depicts the GUI for selecting database image. The GUI contains options for segmentation, fruit localization, texture feature and fuzzy classifier.

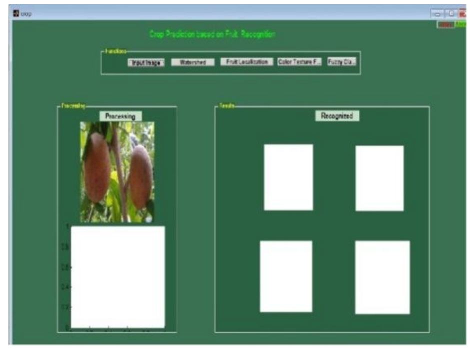

Figure 7. GUI for selecting database

After selecting a chikku image from database, the GUI looks as shown in figure 7.

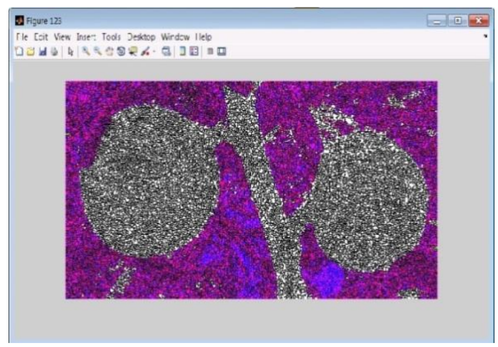

Figure 8. Result of crop image segmentation

The figure 8 shows the segmented result for a chikku image, using watershed technique. The GUI includes only fruits part of a given image and the fruits are shown in different colour. The geometrical attributes are the different shape features of a chikku, the results are

Table 1. Effective shape features for selected fruit images

Shape feature v/s fruit	**Apple**	**Sapodilla**	**Orange**	**Guava**	**Mango**
Aspect ratio	1	1.24	1.36	1.52	1.63
Elongation	0.23	0.38	0.42	0.55	0.28
PTB	2.1510e-006	26810e-006	24810e-006	25610e-006	27610e-006
LTW	1.0233	1.0456	1.0873	1.0463	1.0749
LTP	295.603	296.603	295.848	294.761	295.861
Compactness	100	100	100	100	100
Cube of perimeter	5.1619e-010	5.1836e-010	5.1639e-010	5879e-010	57389e-010

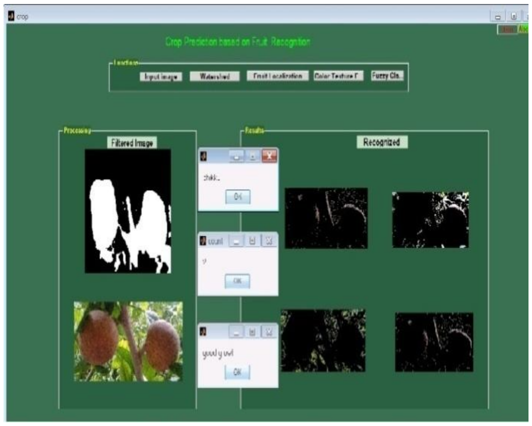

Figure 9. GUI to show the result

The figure 9 shows the result of given fruit image. Later by applying sobel operator and morphological operation count of fruits are presented. And shows the classification based on threshold assumed in the work the crop growth is predicted.

V. Conclusion And Future Scope

The proposed paper presents work fruit image recognition. The image is segmented by watershed technique. The feature extraction such as shape, colour and texture are applied. The fruit region is extracted using circle fitting. By using fuzzy classifier it will classify recognize the fruit from a crop. The resultant recognizes fruit were used as a count of total number of fruits in an image for small database.

Future scope can be extracted by including better segmentation and feature extraction. The work is finds an application in field and horticulture.

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