Real Time Automatic Bruise Detection in (Apple) Fruits Using Thermal Camera

Dhanashree Jawale and Manjusha Deshmukh

***Abstract*—New sheltered and quick techniques for evaluating of fruits have critical place in agricultural economy. At present times traditional grading methods have been used broadly. But high cost and some inconsistencies guide post harvesting industry led to automation applications in classification operations.**
Recent, Undertakings slant towards mechanization frameworks for expanding working limit and diminishing working expenses. Inconsistencies associated with manual grading decrease when automated grading systems are used. Thus, error rate and costs decreases while speed increases. As known size, shape, shading and tissue are fundamental criteria the classification procedure. In this study, automatic evaluation by utilizing thermal camera and modernized image processing method is proposed. It is very tedious and hectic job to monitor fruit bruise manually and time consuming process so BDS (bruise detection system) is used for the detection of fruit diseases. Tedious human inspection task for sorting fruits is reduced by designing an automated system consisting of developed algorithm and conveyer platforms.

***Index Terms*—Artificial Neural Network (ANN), Grey Level Co-occurrence Matrix (GLCM), K-means Clustering Segmentation, Thermal Imaging.**

I. INTRODUCTION

India is an agricultural nation where around 70% of the population relies on farming. Farmers have extensive variety of differences to choose reasonable food grown from the ground crops for ideal yield and quality created is very specialized. It can be enhanced by technological support. As known size, shape, shading and tissue are fundamental criteria in the classification procedure.

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The administration of fruit wounds requires observation that can influence generation altogether and consequently the post reap life. Fruit wounds have transformed into a bad dream as it can bring about critical lessening in both quality and amount of horticultural items, along these adversely affected nations that are agribusiness subordinate economy basically rely on farming on its economy. Yuhki Shrivaishi, this algorithm of inspecting shape uses only some rectangle of object. Therefore difference of shapes is not proper for classification result[1]. K. vijayrekha, in her paper discusses multivariate image analysis technique[2]. Brench Yana they uses neural network for spheres of object classification[3]. The proposed SHEM algorithm gets less time than the std. EM algorithm[4]. They represents GUI technology that helps medical professionals to get idea about patient bruising[5]. They concluded that average of cross correlation that happens to be better result for classification of apple[6]. For classification and detection all have been using k-means clustering and glcm algorithm method[7-13]. After detection and segmentation , they used ANN for classification of fruits and leaf but using IR and web camera.[14-16]. The time spent for accumulation , stockpiling and transportation of fruit in the end endure vibration affect and different sorts of harm fruit restrain in their previous quality. The important commitment of works is created by physical model that contain the exhibited outwardly diagrams in other paper regard to utilized the artificial neural and co-occurence method all features utilizing thermal procedures, in a genuine model capable of recognize wounds in fruit progressively. Image analysis can be applied for the following purposes.

-To detect bruises in fruits
-To find boundary of the affected area
-To classify fruits

The section II describes the system model and assumption. Section III discuss about the result performance. At last, section IV and V concludes the paper and future scope respectively.

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II. SYSTEM MODEL AND ASSUMPTION

With increased expectation of high quality and safety in food products, the experiment represents method of detecting bruises by image processing which includes capturing of images, processing and analyzing the thermal images and assessing the visual quality characteristics in fruits by non-destructive method.
This project not only aims to detect a bruise in fruit as well as to reduce the wastage of the fruits during storage time. “Fig. 1” shows basic step of algorithm.

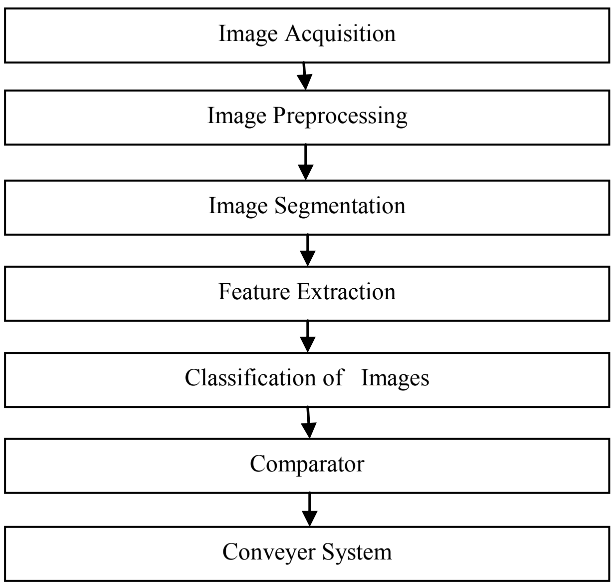

Fig. 1. Basic steps for apple fruit detection

A. *Image Acquisition*

The images of the fruits are caught through the thermal camera (RGB picture). Image obtaining is the initial phase in framework advancement to get the specimen or the image. “Fig 2” shows web cam image and thermal image.

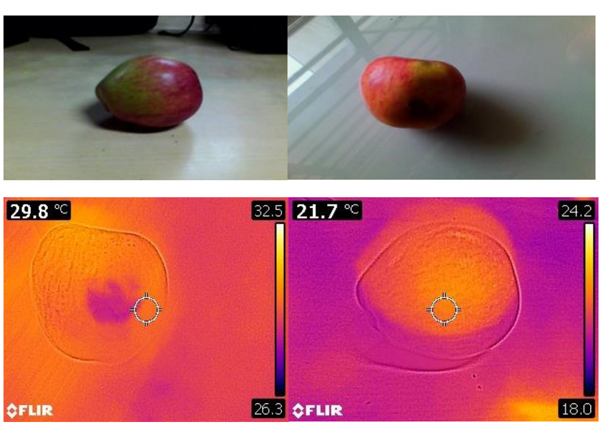

Fig. 2. Web cam image and thermal image

B. *Image Pre-processing*

In pre-processing, noise shown in image is evacuated and also image upgradation is finished. Image improvement is finished by utilizing contrast stretching. Intensities are distributes using histogram equalization. Histogram applies on the image for enhancement of fruit image.

C. *Image Segmentation*

Image segmentation implies dividing of image into different parts having same components or closeness. The division is done utilizing different techniques k-means clustering, "otsu" strategy and changing over RGB picture into HIS model and so forth.

Converting RGB to gray scale image

The segmentation and pre-processing undertaking are the underlying stage before the picture is utilized for the following procedure. The principle target of this procedure is to acquire the binary image. The RGB gray scale is the such a particular segment of a similar hued pictures. Where in one pixel point change in the range between 0-255, the same as the depiction of the shading image of the grey scale image.

D. *K-means clustering*

Image Color Segmentation utilizing K-Means clustering. Change over Image from RGB Color Space to L*a*b* Color Space and The L*a*b* space comprises of a radiance layer 'L*', chromaticity-layer "a*" and "b*" yet all shading data is in the "a*" and "b*" layers. Arrange the hues in a*b* shading space utilizing K-implies grouping. Since the image can have 3 hues make 3 groups. Measure the separation utilizing Euclidean Distance technique. Condition of the Euclidean separation technique is given as follows.

$$D(i,j) = \sqrt{(x2-x1)^2 + (y2-y1)^2} \qquad \text{(a)}$$

E. *Feature Extraction*

Color and texture features can be used to identify bruise fruit and non bruised fruit.

Color co-occurrence Method
Let i and j are the coefficient of co-occurrence matrix at the co-ordinates (i,j) and N is the dimension of the co-occurrence matrix.
Texture extraction

Energy (E) can be characterized as the measure of the degree of pixel match repetition. It gauges the consistency of a image. At the point when pixels are fundamentally the same as, the vitality esteem will be vast. It is characterized in Equation as.

$$En = \sum_{i=0}^{Ng-1} \sum_{j=0}^{Ng-1} P_{d,\theta}\ (i,j)^2 \qquad (1)$$

Entropy(E) Texture of the image is characterized by using entropy. Its esteem will be greatest when every one of the components of the co-event framework are the same. It is additionally characterized as in Equation as

$$Ep = \sum_{n=0}^{Ng-1} n^2 \left\{ \sum_{i=0}^{Ng-1} \sum_{j=0}^{Ng-1} P_{d,\theta}\ (i,j) \right\} \qquad (2)$$

The contrast (Con) is characterized in Equation, is a measure of power of a pixel and its neighbor over the picture.

$$Con = \sum_{i=0}^{Ng-1} \sum_{j=0}^{Ng-1} P_{d,\theta}\ (i,j) \log\left(P_{d,\theta}(i,j)\right) \qquad \mathbf{(3)}$$

Variance is measure of the scattering of the qualities around the mean of mix of reference and neighbor pixels.

$$F4 = \sum_{i=0}^{Ng-1} \sum_{j=0}^{Ng-1} (i-\mu)^2 P_{d,\theta}(i,j) \qquad (4)$$

Correlation : Linear dependency of grey level matrix depends on value of correlation feature in co-occurrence matrix. It speaks to how a reference pixel is identified with its neighbor, 0 is uncorrelated, 1 is flawlessly related.

$$F5 = \sum_{i=0}^{Ng-1} \sum_{j=0}^{Ng-1} P_{d,\theta}(i,j) \frac{(i-\mu_x)(j-\mu_y)}{\sigma_X \sigma_Y} \qquad (5)$$

Inverse Difference Moment acquires the measures of the closeness of the circulation of the GLCM components to the GLCM advanced. IDM weight esteem is the reverse of the difference weight, with weight diminishing exponentially far from the corner to corner.

$$F6 = \sum_{i=0}^{Ng-1} \sum_{j=0}^{Ng-1} \frac{1}{1+(i-j)^2} P_{d,\theta} \qquad (6)$$

Mean moment1: average value of pixel denoted by mean.

$$M1 = \sum_{i=0}^{Ng-1} \sum_{j=0}^{Ng-1} (i-j)\, P_d(i,j) \qquad (7)$$

Standard Deviation moment (m2) is the standard deviation that can be denoted as follows
It shows difference between group values of mean and group values of standard deviation.

$$M2 = \sum_{i=0}^{Ng-1} \sum_{j=0}^{Ng-1} (i-j)^2\, P_d(i,j) \qquad (8)$$

Skewness (degree of asymmetry**)** m3 skewness is asymmetry in measurable conveyance in which bend seems contorted or skewed either to left side or right . Skewness can be evaluated to characterize the degree to which a circulation contrasts from a typical conveyance.

$$M3 = \sum_{i=0}^{Ng-1} \sum_{j=0}^{Ng-1} (i-j)^3\, P_d(i,j) \qquad (9)$$

Kurtosis m4
kurtosis shows how the peak and tails of conveyance contrast from the normal distribution .Use kurtosis to help you at first comprehend general qualities about the dissemination of your information.

$$M4 = \sum_{i=0}^{Ng-1} \sum_{j=0}^{Ng-1} (i-j)^4\, P_d(i,j) \qquad (10)$$

F. Classification

Artificial Neural Network:

Now, Extract another features from the segmented image form k means clustering. Convert RGB image to grayscale then convert gray scale image to black and white using otsu' method. Create the Gray Level Co-occurrence Matrices (GLCMs) from black and white image and following parameters are calculated using GLCMs matrices (Contrast, Correlation, Energy, Homogeneity, Mean, Standard Deviation, Entropy etc). The SVM is characterized for two class issues it searched for ideal hyper-plane, which amplified the separation, edge between the closest cases of both classes, named SVM. A present well known characterization apparatus utilized for example acknowledgment and other arrangement purposes. SVM are a gathering of directed learning techniques that can be connected to characterization or relapse. The standard SVM classifier takes the arrangement of information and predicts to group them in one of the main two particular classes.

TABLE I

BRUISED APPLE FEATURE VALUES AND AVERAGE

SR.	Contrast	Correlation	Energy	Homogeneity	Mean	Standard Deviation	Entropy	RMS	Variance	Kurtosis	Skewness
1	0.077466	0.976901	0.216497	0.964088	141.6781	94.94981	7.315724	14.94303	1389.599	1.472495	-0.20421
2	0.049862	0.932937	0.512426	0.977388	128.0923	86.5885	7.47912	15.646	581.5862	1.590145	0.298425
3	0.086673	0.922861	0.32482	0.958212	128.9117	85.09177	7.620928	15.56965	944.9109	1.578418	0.253282
4	0.236366	0.954116	0.156893	0.947029	118.6574	83.34539	7.721967	14.83257	3026.451	1.773452	0.203181
5	0.059252	0.921537	0.542871	0.972489	128.2028	86.15181	7.456064	15.65233	738.6721	1.601792	0.271131
5	0.059252	0.921537	0.542871	0.972489	128.2028	86.15181	7.456064	15.65233	738.6721	1.601792	0.271131
6	0.151088	0.870574	0.306784	0.947619	128.6103	84.43726	7.54807	15.58015	964.445	1.581423	0.290953
7	0.077466	0.976901	0.216497	0.964088	141.6781	94.94981	7.315724	14.94303	1389.599	1.472495	-0.20421
8	0.199127	0.80731	0.381511	0.93921	128.8658	86.84223	7.581385	15.45988	681.6582	1.590607	0.245114
9	0.146875	0.848366	0.544284	0.955222	127.7109	87.73416	7.380907	15.61067	926.8716	1.593964	0.274006
10	0.215977	0.957685	0.158568	0.948775	117.8747	82.96534	7.723272	14.79905	3093.266	1.782691	0.200111
11	0.215977	0.957685	0.158568	0.948775	117.8747	82.96534	7.723272	14.79905	3093.266	1.782691	0.200111
Average	**0.13783**	**0.920625**	**0.319974**	**0.956627**	**128.0143**	**86.91104**	**7.533312**	**15.25776**	**1530.029**	**1.620016**	**0.166171**

TABLE II

NON BRUISED APPLE FEATURE VALUES AND AVERAGE

SR.	Contrast	Correlation	Energy	Homogeneity	Mean	Standard Deviation	Entropy	RMS	Variance	Kurtosis	Skewness
1	0.108379	0.803448	0.472913	0.963562	126.9543	78.07681	6.975387	15.96116	279.7015	1.561969	0.575104
2	0.185049	0.711326	0.385416	0.932317	128.4483	81.74137	7.11903	15.916	309.6583	1.53736	0.508311
3	0.223836	0.748505	0.390935	0.926354	125.1412	79.0795	7.072168	15.85425	491.9569	1.611111	0.561367
4	0.180744	0.765704	0.378899	0.93593	127.328	81.564	7.304746	15.83024	425.7415	1.580306	0.475207
5	0.144271	0.799758	0.439971	0.954872	125.8577	77.83339	7.126363	15.91721	480.8996	1.600678	0.562859
6	0.092249	0.893519	0.422945	0.962094	126.385	82.04328	7.157739	15.81779	488.1731	1.589244	0.507614
7	0.246078	0.789712	0.387186	0.936309	125.8271	83.15916	7.184816	15.78425	693.0614	1.596352	0.505208
8	0.153968	0.813576	0.4417	0.957986	126.0657	80.15906	6.99549	15.81943	569.606	1.602337	0.528189
Average	**0.166822**	**0.790693**	**0.414996**	**0.946178**	**126.5009**	**80.45707**	**7.116967**	**15.86254**	**467.3498**	**1.58492**	**0.527982**

TABLE III

NON BRUISED APPLE FEATURES AND BRUISED APPLE FEATURE TABLE COMPARISON

SR.	Contrast	Correlation	Energy	Homogeneity	Mean	Standard Deviation	Entropy	RMS	Variance	Kurtosis	Skewness
Non Bruised	0.166822	0.790693	0.414996	0.946178	126.5009	80.45707	7.116967	15.86254	467.3498	1.58492	0.527982
Bruised	0.13783	0.920625	0.319974	0.956627	128.0143	86.91104	7.533312	15.25776	1530.029	1.620016	0.166171

III. PERFORMANCE RESULT

This system consists of two main parts software and Hardware, Software is nothing but an ANN (Artificial Neural Network) algorithm and Hardware is conveyer based fruit sorting system. The results are shown in "Fig. 3" shows clustering result of fruit. "Fig. 4,5" shows result of bruised and non bruised detection. From mentioned statistical analysis in "Table I,II,III" we can draw conclusion for bruised and non bruised fruit. Table indicates comparison between values of bruised feature vector and non bruised feature vector. The average of grey level co-occurrence method features in each section of apple fruit shows in Table1 and Table 2.These data are utilize for algorithm to detection of bruised in fruit.

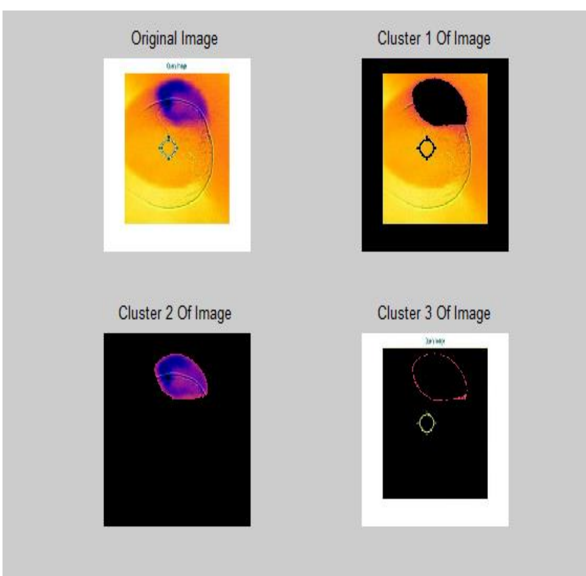

Fig. 3. Result of clustering

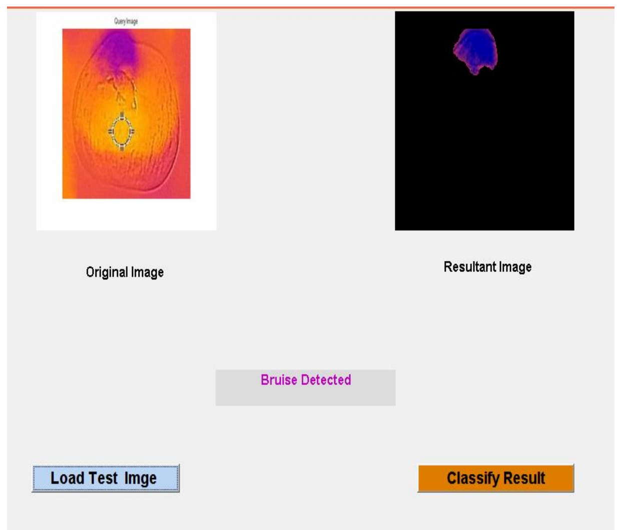

Fig. 4. Result of bruised fruit

Fig. 5. Result of non- bruised fruit

IV. CONCLUSION

We have already tested some activity calculations for the decision of bruising in apple by occurring co-occurrence feature values. The effect of bruised region of apple was not perceivable with naked eye. Therefore we can expand prototype hardware and software algorithm for capture, rotation and automatic detection of bruising in apple. The method gives best result in calculating features of co-occurrence matrix. This data are average and compared with bruised and non bruised feature averaged with data in each section of same fruit. This disposes of subjectivity of customary techniques and human prompted errors. Conveyer system reduced staff of the centre. We have used thermal camera to detect internal disorder of the apple. Working in real time by using ANN we get sufficient speed and accuracy. We have checked web cam image efficiency. and thermal camera image efficiency. Results of thermal camera are really better than results of web camera. Image processing and analysis are recognized by computer vision. Tedious human inspection task will be reduced by series of image processing operations.

V. FUTURE SCOPE

As here we are trying to detect only some numbers of sample of bruised fruits. In future we can also implement for more types of bruises. We can also work on the different features of image classification. We can improve this, so that it can be used to detect bruises for others fruit too. Also it's a standalone application to improve the system so that it can support a web interface.

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