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Physical Parameters Extraction of Fruit Mango Using Image Processing In MATLAB

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ABSTRACT: Automated Quality Testing And Grading Of Agriculture Products Is Becoming More Interesting Research Area In Current Time. Combination Of Image Processing And Computer Vision Systems Is Playing Vital Role For Accomplishing This Task. Quality Testing And Grading Of Mangoes Based On Damaged Area Identification And Ripeness Detection Is The Hercules Process For The Computer Vision To Recognize Next To Human Levels Of Detection. This Research Work Includes The Automated Quality Testing And Grading Of Mangoes Based On Maturity, Size, Shape, Texture And Surface Defect. The Research Project Can Be Helpful And Used In Computer Vision For The Farmers And Customers Both In The Form Of Decreasing Labor At And Sorting Of Quality Products To Customers .We Are Using MATLAB For Extracting Image Features And ANN For Classification. This Paper Focused On The Grading Of Mangoes Based On Surface Defect, Size And Maturity. K-Means Clustering Algorithm Is Used For Surface Defect Detection And Mean Values Of RGB Colors Is Used For Maturity Identification.

Keywords: Computer Vision , K-Means Algorithm , ANN, MATLAB,RGB .

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I. INTRODUCTION

Non–Destructive Techniques For Grading And Sorting Of Agriculture Products Are Becoming Popular In Agriculture Industries. In This Era Computer Vision Is Playing Vital Role. The Computer Vision Technology Has Potential Of Grading Agriculture Products Very Effectively Due To Its Characteristics Like Real-Time, Nondestructive Etc. This Technology Can Detect Various Physical Parameters Shape, Size, Surface Defect, Texture Etc Simultaneously. Computer Vision Is Now Becoming More Popular Quality Evaluation Tool For Producing Non-Destructive Results In The Food Industry [10].Machine Learning Based Non-Destructive Technique Using Color As A Grading Parameter Has Been Used In Various Agricultural Applications. Peach Grading Based On Color Vision System Is Discussed In Paper [8], Computer Vision Based Date Fruit Grading System [13], Grading And Sorting Of Strawberry [17], Color Based Grading Of Food Products [26], Color Based Grading Of Palm Oil Fresh Fruit Bunches [20], Apples[12], Oranges[21], Lemons[3] Many Of These Systems Yield Promising Results. In Most Of The Applications First The Image Is Captured In RGB Components, Second This Is Converted Into HSI Color Model.

Image Processing With Computer Vision Is Widely Used By Various Researchers For Detecting Surface Defects, Maturity And Graded The Mangoes Based On Identified Defects And Maturity Level Using Either RGB Images Or Multispectral Images. Generally Grading Of Mangoes Is Done By Extracting Physical Parameters. In India This Is Processed Manually And Result Accuracy Depends On The Expertise Knowledge. In Current Time Agriculture Product Categorization And Grading Is Moving Towards Automation For Increasing Accuracy And Inconsistency In Produced Results. Agricultures Industries Are Moving Towards The Automated Classification Of Food And Food Products Such As Grading On Peaches And Oranges [1]. A Comparative Study Of Basic Segmentation Techniques Like FCS And OTSU's Is Disused In Comparison With Improved Thresholding Based Segmentation With An Inverse Technique (Tstn) [1]. Performance Of Segmentation Techniques Is Compared RI. Tstn Based Image Segmentation Quality Is High As Compared To Other Two.

An Optimal And Adaptive Threshold Method Is Used For Segmenting Mango From Its Background [26]. In Pre-Processing Phase Color Image Is Converted Into Gray And Binary Image With Median Filter For Removing Noise. Defective Area Is Evaluated By Image Area/Defective Pixels.A

K-Means Clustering Algorithm Is Used In Image Segmentation Process For Automatically Detection Of Pomegranate Fruits [10].Accuracy Of Segmentation Results Produced By K-Means Algorithm Depends On The Image Defining Procedure. Image Segmentation Is Performed By Taking Pixel Color And Spatial Feature In Consideration. Clustered Blocks Are Merged For Image Retrieval. Dubey's (Dubey Et Al., 2013) Methodology Of Using K-Means Clustering Algorithm For Simple And Straightforward Image Segmentation Is Used[4]. An Image From RGB Space Is Converted Into L*A*B Color Space. Image Is Segmented At Different Values Of K=2,3,4. Segmentation In 2 To Three Clusters Has The Mixed Pixel Problem .For The Better Result Image Is Segmented Into Four Clusters.

Surface Color Features Of Fruit Are Extracted Then Segmented The Defective Part Of Fruits Using K-Means Clustering And Fuzzy C-Means Algorithms [11]. Gaussian Low-Pass Filter (GLPF) Is Used For Removing Noise. K–Mean Clustering Algorithm Is Used For The Defect Segmentation Of Fruits [13]. Three To Four Clusters Are Used For Defect Segmentation. For Experimental Result Defected Apples Are Used As A Case Study.In Addition Of This ANN (Artificial Neural Network) And Genetic Algorithms Are Also Used For Image Segmentation [11].

The Study Of Mangoes Using Computer Vision Has Been Used For Producing Non Destructive And Optimized Results Fruit Grading And Classification Using Physical Parameters Like Shape, Surface Defect And Ripeness As An Input. As Surface Defects, Maturity And Size Are Of Great Concern To Producers For Grading The Mangoes. The Grading System Utilizes Computer Vision Techniques To Detect The Defects On The Surface Of Mangoes And To Predict Maturity. After Identifying The Maturity And Surface Defects Of Mangoes, The System Grade The Mangoes Based Upon This Criterion. The Defects Or Damage In Mangoes Is Usually Considered In Terms Of Bruising, Scab, Fungal Growth, Injury, Disease And Other Defects Must Be Removed To Prevent Cross-Contamination And Reduce Subsequent Processing Cost. This Paper Focused On To Develop An Algorithm For Identifying Surface Defect And Maturity Of Mango Fruits Using RGB Color Model. Finally Mangoes Will Be Graded And Classified Based On Ripeness, Shape, Size And Surface Defect Using Digital Image Analysis.

II. PROPOSED ALGORITHM

Mango Grading And Quality Testing Algorithm Includes 7 Steps:

1. Image Acquisition.
2. Image Pre-Processing.
3. Shape Based Categorization Of Mangoes.
4. Image Feature Extraction.
5. Image Feature Selection.

Classification Based On ANN And SVM

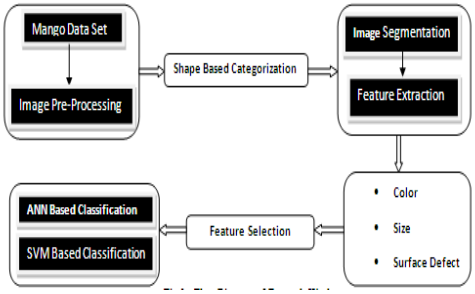


Fig 1: Flow Diagram Of Research Work

III. MATERIALS AND METHODOLOGY

Rest Part Of This Section IV Describes The Used Methodology For Grading And Sorting Of Mango Fruits. In The First Phase Of Project MATLAB Is Used For Feature Extraction. Color, Size, Shape, Surface Defect And Texture Features Are Extracted As External Quality Parameters. In Second Phase Of Classification We Will Use BPNN And SVM. In Rest Of This Paper We Discussed Used Methodology For First Part Of Project.

A) Data Set Of Mangoes/Image Capturing

As A Database 100 Samples Of Mangoes Are Selected At Different Maturity Stage From Web [25].Photography Has Done In Both Sides. EOS 550D And Canon Inc. Digital Cameras Are Used For Image Acquisition Having High Quality. Image Size Is 1200*800 Pixels With Resolution .03mm/Pixel. File Format Of Image Is JPG.

Data Was Collected By Taking Image Of Each Sample Individually .This Inspection Chamber Contains A Camera And Lighting Source. The Images Were Taken By Placing Each Sample Inside An Inspection Chamber. The Used Vision System For Acquiring The Images Is Shown In "Figure 2". Distance From Sampled Data Was 20 Cm For Each[25].

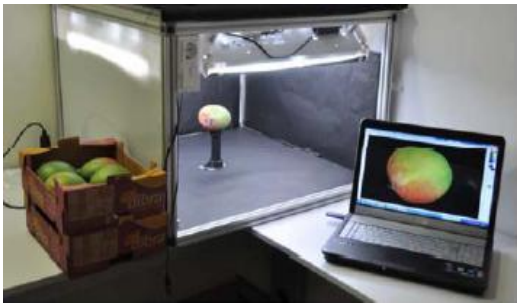


Fig 2: Image Capturing

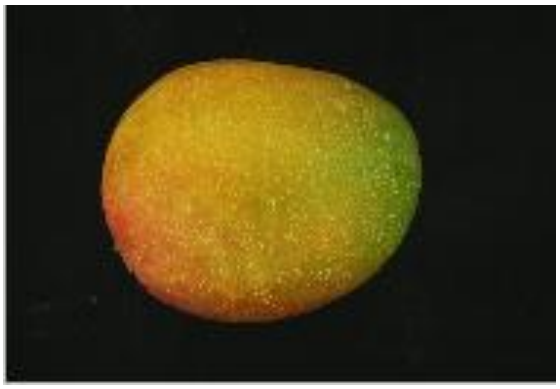
B) Image Pre Processing: In Image Pre Processing Technique For This Project Contrast Stretching And Noise Filtering Operations Are Used. Median Filtering Is Used For The Noise Removing And Histogram Modification Is Used For Better Picture Display. A Threshold Value Is Set For Image Segmentation. Then Binarization Threshold Was Estimated From The Image Intensity Histogram.

IV. EXTRACTED FEATURES AS QUALITY PARAMETERS

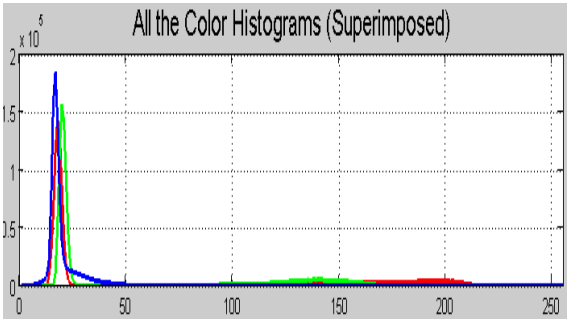
In Our Research External Quality Parameters Of Fruit Mango Are Selected As A Quality Assessment Features Such As Color, Size, Shape, Texture And Defects. In Rest Of This Part Feature Extraction Methodology Is Described.

A) Color

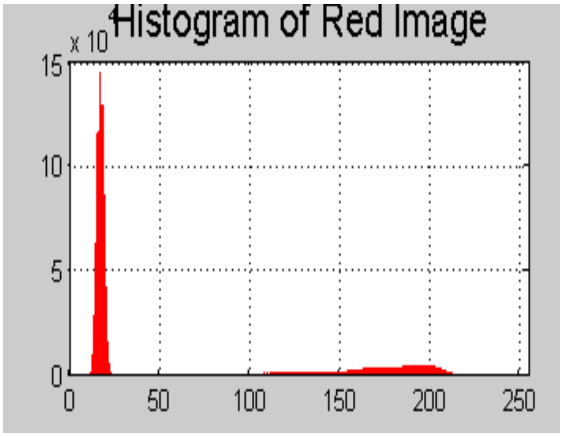
Color Is One Of The Prominent Features Used By Farmers For Predicting The Maturity Of Fruit. A Huge Number Of Color Extraction Algorithms Has Discussed By Researchers Like:.In This Paper We Discussed The Color Histogram Technique For Maturity Prediction Of Mangoes Selected As A Case Study. RGB Color Mean Value Of Each Color Is Calculated At Each Color Band. In Fig 3 (A) Is The Original Image, (B) Is The Superimposed Color Histogram Of Image In (C),(D) And (E) Color Histogram Is Used Individually.



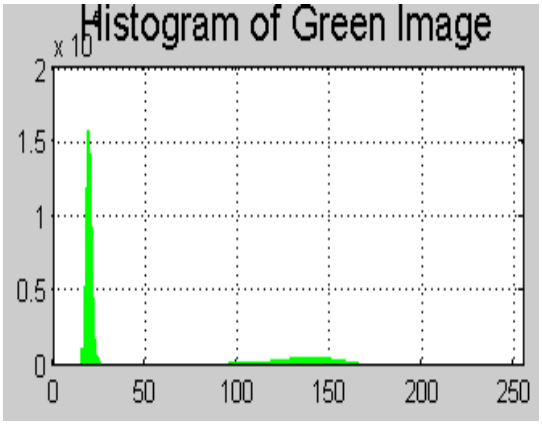
(3 A)



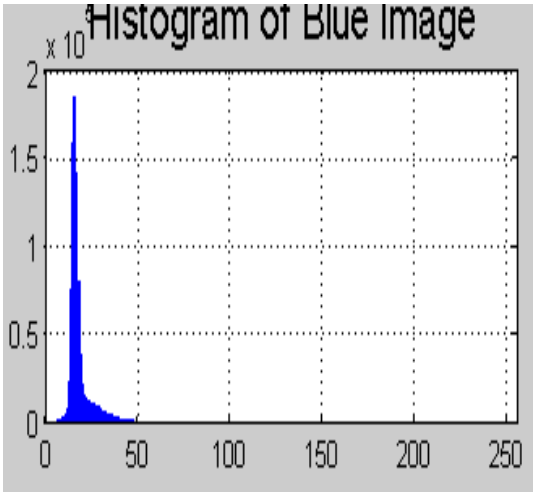
(3b)



(3c)



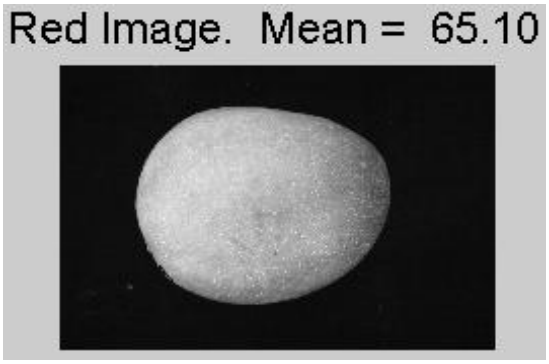
(3d)



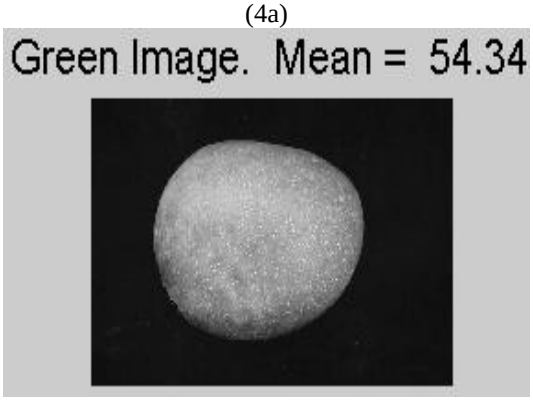
(E)

Fig 3 : Fruit Maturity Prediction Using Histogram

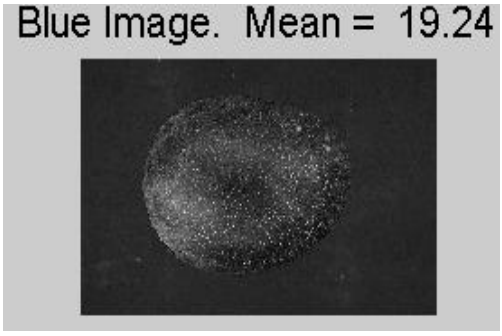
Fig 3 (A),B) And (C) Represents Color Mean Of Each Color At Red Channel , Green Channel And Blue Channel Respectively.



(4a)



(4b)



(4c)

Fig 4 : Fruit Maturity Prediction Using Color Mean Values In Each Color Band

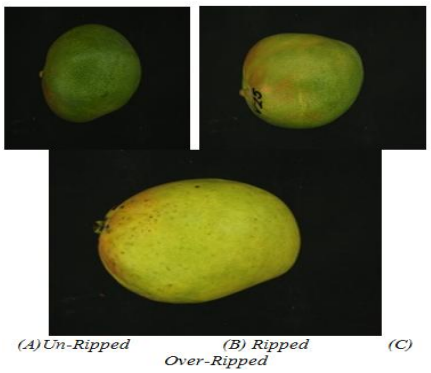


Fig 5: Mango In Different Ripping Stages

B) Size

Fruit Size Is Also An Added Quality Aspect Mostly Used By Farmers – The Better Size Fruit Is Considered Of Better Quality. In Fruit Size Estimation Area Covered By Fruit Image Is Evaluated. For This Computation, First We Used Image Binarization Process In Image Processing For Extracting Fruit Image From Its Background. In Fruit Size Evaluation Two Methods Are Used. The One, Total Number Of True Pixels Is Calculated And In Second Method Major And Minor Axis In Binarized Image Is Evaluated. We Categorize Fruits In Three Classes Based On Their Size As A Big, Medium And Small Using The Average Area Of Images.

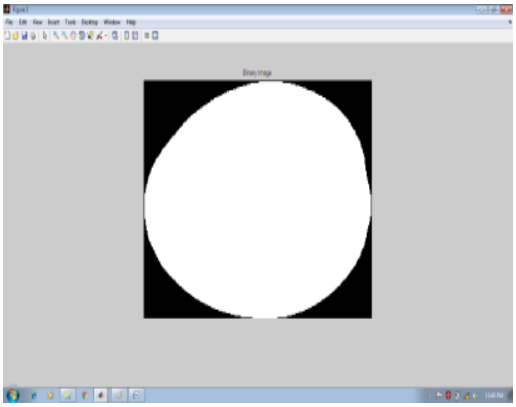


Fig 5: Image Area Calculation

C) Surface Defect

Surface Defect Is One Of The Most Considerable Parameter Used By Farmers/Customers For Fruit Categorization. In This Process Damaged Part On Surface Of Mango Is Detected For Defected Categorization. A Finding Related To Defected Mangos Is Performed Using Surface Defect As An Input Parameter That Includes Scars, Dark Spots, Etc. K-Means Clustering Algorithm Is Used For Surface Defect Detection By Segmenting Image Into Three Clusters. Clustered Image Having High Intensity Of Damaged Part Is Selected To Calculate Defected Area On The Surface.

% Of Defected Area= (Number Of Defected Pixels/ Total Number Of Pixels)*100.

Two Classes Are Created For Mangoes Identification One For Healthy Mangoes Second For The Unhealthy Mangoes. Median Filter Is Used For Image Filtering. Pixels Inside The Selected Clustered Image Are Counted For Evaluation Of Surface Defect. In Fig 6 (A) Is The Original Image (B),(C) And (D) Are Clustered Images Using K-Means Algorithm.

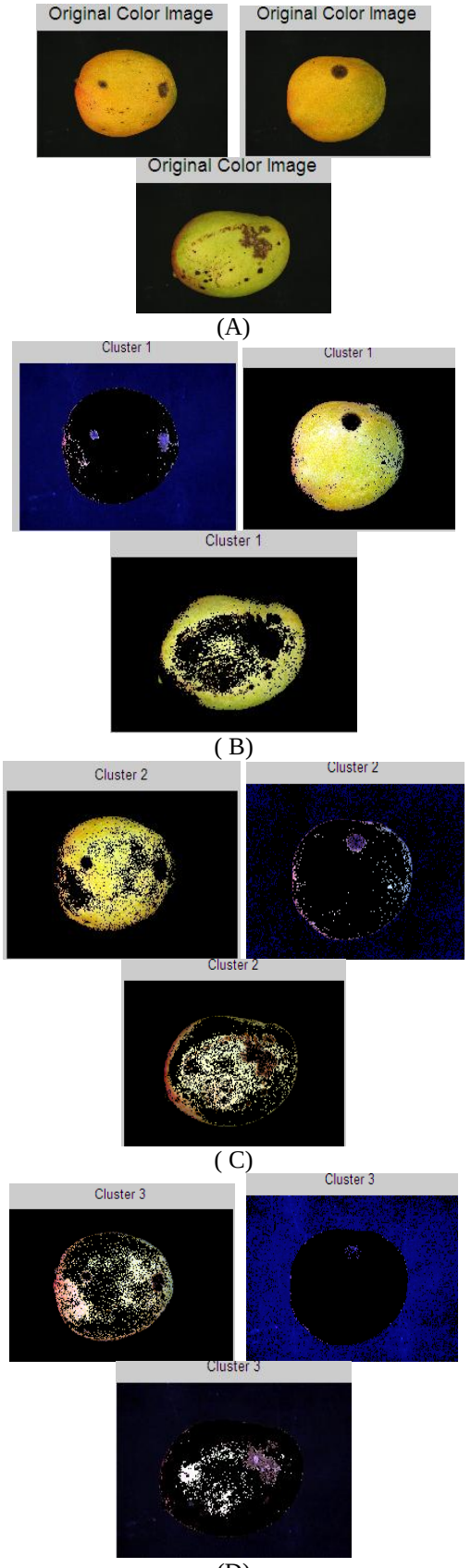


Fig 6: Surface Defect Evaluation Using K-Means Image Segmentation Algorithm

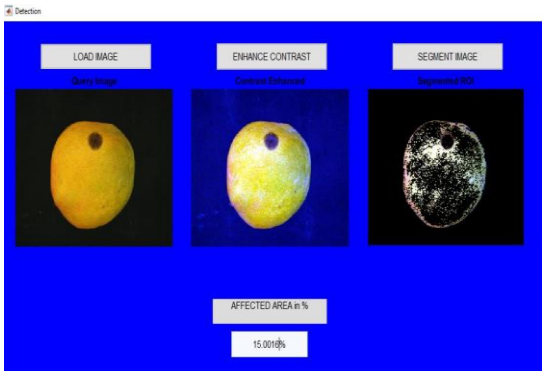


Fig 7: Extracted Infected Area Using K-Means

D) Texture Feature Extraction

In Texture Analysis Essential Characteristics Of Textures Are Evaluated For Representing Them In Some Simpler But Distinctive Form. So That An Accurate Classification And Segmentation Of Objects Can Be Processed. Texture Features Extraction Methods Classified In The Categories As Structural, Statistical, Model-Based And Transform (Neville Et Al 2003).

A) Structure Based Feature Extraction

A Well Defined Primitives And Hierarchy Representation Of These Primitives Is Used For Texture. Primitives Defining Way Is The Key Point For Texture Description. This Method Provides The Good Symbolic Description Of Image, More Popular For Image Synthesis Than Analysis Tasks.

B) Statistical Based Feature Extraction

Texture Is Characterized In Non-Deterministic Properties Of Image And Used For Managing The Relationship Between The Gray Levels Of An Image. Local Features Of Each Pixel Is Computed For Analyzing Spatial Distribution Of Image Gray Values And A Set Of Statistical Values Is Derived. The Statistical Methods Are Generally Classified Into First Order (One Pixel), Second Order (Pair Of Pixels) And Higher Order (Three Or More Pixels) Statistics. The First Order Method Individual Pixel Property Is Estimated. Second And Higher Order Statistics Estimate Properties Of Two Or More Pixel Values Occurring At Specific Locations Relative To Each Other. In Statistical Based Texture Feature Extraction Method Most Popular Is Second Order Statistics. The Most Popular Second Order Statistical Features For Texture Analysis Are Derived From The Co-Occurrence Matrix Discussed In Section 4.1

C) Model Based Feature Extraction

Model Based Methods Are Based On Image Structure For Describing Image Texture And Synthesizing It. Image Is Described As Probability Model Or As A Linear Combination Of A Set Of

Basic Functions. The Fractal Model Is Useful For Modeling Certain Natural Textures That Have A Statistical Quality Of Roughness At Different Scales And Self Similarity, And Also For Texture Analysis And Discrimination.

D) Transform Based Feature Extraction

In Transform Based Feature Extraction Methods Like Fourier, Gabor And Wavelet Transforms An Image Is Represented In Form Of Space And Interpretive Coordinate System Is Closely Related To The Texture Characteristics. Fourier Transform Method Has Weakness In Spatial Localization. Transform Methods Process The Complete Image That Is Not Good For Applications In Which Selected Part Of Image Is To Be Processed.

4.1 STATISTICAL BASED FEATURES

The Three Different Types Of Statistical Based Features Are First Order Statistics, Second Order Statistics And Higher Order Statistics As Shown In Figure 8.

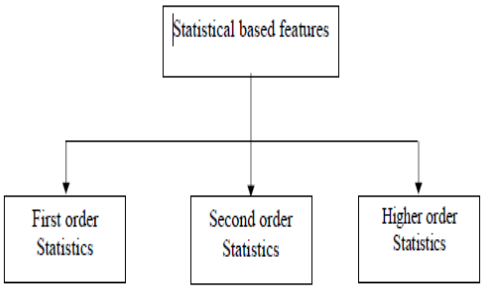


Figure 8: Statistical Based Texture Features

In This Research Work GLCM Is Used For Evaluating Statistical Texture Features. A Number Of Texture Features May Be Extracted From The GLCM.

A) Comparison Of Texture Analysis Methods

A Number Of Researchers Have Worked On Texture Extraction Methods And Their Comparison. Comparison Of GLCM And Fourier Methods(Dulyakarn Et Al ,2000), Comparison Of GLCM And Fourier Spectra For Image Classification(Maillard ,2003) ,Comparison Work Of GLCM ,Wavelet Texture Analysis (Bharati Et Al.,2004) In All These Research Work GLCM Approach For Texture Analysis Of Image Is More Effective As Compared To These All.

B) Texture Features Extracted Using GLCM

GLCM Matrix Is Created By Taking Directions And Distances Between Pixels Of Image As An Input And Statistical Data Is Extracted From The Matrix In The Form Of Texture Features. Number Of Rows And Columns In GLCM Square Matrix Is Equal To The Number Of Gray Levels In The Image. GLCM Composition Is Based On Probability Value Defined As P (I,J|ΔX,ΔY) Where ΔX And ΔY Represents The Probability Of Paired Pixels At ΔX Direction And ΔY Intervals Respectively.

In GLCM Elements Are Computed By The Equation:

$$P(I,J|\Delta X,\Delta Y)= \frac{P(I, J|\Delta X, \Delta Y)}{\sum\sum P(I ,J|\Delta X, \Delta Y)}$$

Extracted Texture Features Using GLCM Are Represented According To The Correlation Of The Couple Pixels Gray-Level At Different Positions. Haralick Et Al(1973) Extracted 14 Texture Features From GLCM For An Image. The Important Texture Features Given By Haralic Are Entropy, Energy, Contrast, Inverse Difference Moment(IDM) And Directional Moment(DM). A. Baraldi Et Al(1995) Has Discussed And Given Five Features Energy Entropy, Contrast, IDM And DM And Considered More Relevant In 14 Features. A. Baraldi Et Al Given Texture Features Has Reduced Algorithm Complexity Also.In This Paper Selected Texture Features Are Energy, Contrast, Entropy, Inverse Difference, Correlation, Homogeneity.

Contrast

Reflects Image Clarity And Texture Of Shadow Depth. Contrast Measures Matrix Value Distribution .It Is The Main Diagonal Near The MOI. Contrast Measurement Equation Is:

Contrast $C= \sum\sum (X-Y)^2 P_{ij}$

Contrast Returns A Measure Of The Intensity Contrast Between A Pixel And Its Neighbor Over The Whole Image.

Contrast Varies Between 0 And Size $((GLCM,1)-1)^2$

Contrast Is 0 For A Constant Image.

Correlation

Measures The Correlated Pixels With Neighbors Over The Whole Image

$$Correlation = \sum_{i,j=0}^{N-1} P_{ij} \frac{(i-\mu)(j-\mu)}{\sigma^2}$$

	Red		Green		Blue	
Category	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
Unripe	0	30.35	57.39	99.97	43.52	100
Ripe	28.77	64.63	27.61	69.03	20.8	58.75
Overripe	50.97	100	0	35.30	0	34.4

Correlation Varies Between -1 And 1.

Correlation = 1 If Image Is Perfectly Positively Correlated.
Correlation = -1 If Image Is Perfectly Negatively Correlated.

Energy

Measurement Of Homogeneity Changing, Reflecting Distribution Of Image Gray- Scale Uniformity. Energy Measurement Equation Is:

Energy $E= \sum\sum P_{ij}^2$

Energy Varies Between 0 And 1.For Constant Image Energy=1.

Entropy

Image Texture Randomness Is Measured By Entropy. Co-Occurrence Matrix Value Is Even, Entropy Will Be Min And Co-Occurrence Matrix Is Variant This Will Be Maximum. Entropy Measurement Equation Is:

Entropy $EN=-\sum\sum P_{ij} \text{ Log } P_{ij}$

- Pij Value Will Be Between 0 And 1 It Is A Probability.
- Log Pij Will Be 0 Or Negative.

Inverse Difference

It Measures Local Changes In Image Texture Number. Its Value In Large Is Illustrated That Image Texture Between The Different Regions Of The Lack Of Change And Partial Very Evenly.

Inverse Difference $ID=\sum\sum (1/1+(X-Y)^2) P(X,Y)$

Homogeneity

$$ASM = \sum_{i=0}^{G-1}\sum_{j=0}^{G-1}\{P(i,j)\}^2$$

V. RESULTS AND DISCUSSION

In This Research Project We Are Trying To Develop A Simple, Cost Effective And Efficient Tool For Quality Testing And Grading Of Mangoes Based On Extracted Features Color, Size And Surface Defect And Texture .Maturity Is Identified By Extracted Color Feature. One Standard Value For Color Feature Is Used Given In Table 1. In Our Experiment A Mean Value Is Evaluated For RGB Individually.

Table 1: RGB Values Used For Unripe, Ripe And Over Ripe Mangoes

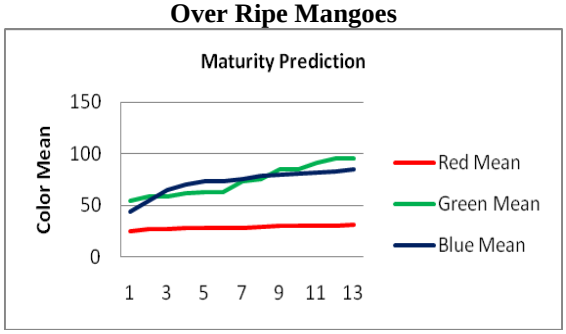


Fig 6 (A) Un- Riped Mangoes

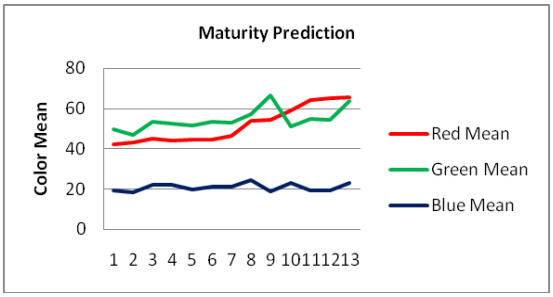


Fig 6(B) Ripped Mangoes

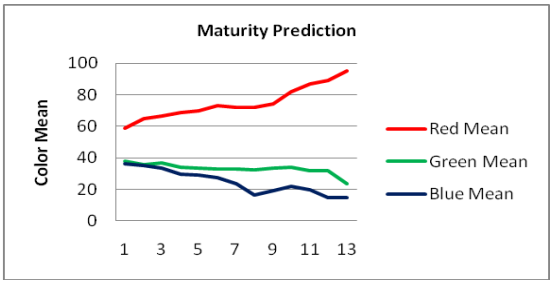


Fig 6(C) Over-Ripped Mangoes

By Using RGB Color Model Extracted Color Features In The Form Of Mean Values Of Each Color Result Is Displayed In Fig (6). Fig (6a) Represents The Color Distribution For Un-Ripped Mangoes. In Un-Ripped Mangoes Color Mean Value Is High For Green Color And Blue Color. In Fig (6b) Color Distribution Value Is High For Red And Green Color Representing Ripped Mangoes. In Fig (6c) Color Distribution Value Is High For Red Color Representing Over-Ripped Mangoes.

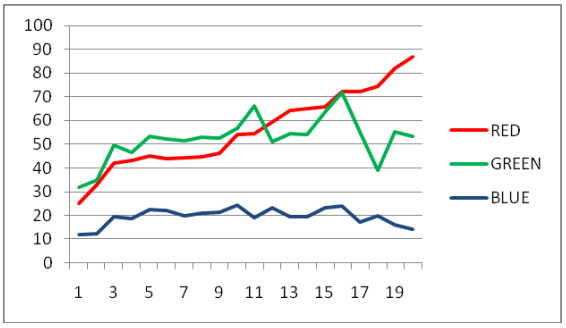


Fig 7 (A): RGB For Healthy Mango

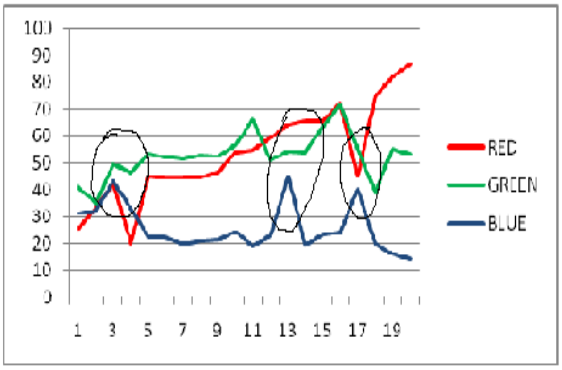


Fig 7 (B): RGB For Defected Mango

GLCM Based Extracted Texture Features Data Is Given In Table2.Texture Feature Is Used To Find Roughness And Smoothness Of Image. In This Paper Based On Extracted Texture Features Two Classes Of Mangoes Are Created Class1 And Class2.

Table 2: Extracted Texture Features Using GLCM

Mango	Contrast	Correlation	Energy	Entropy	Inverse Difference	Homogeneity
Class 1	1.6932	0.7624	.7893	.6504	.8729	3.0980
	1.7682	0.8265	.9726	.7243	.6028	3.2456
	1.8254	.7903	.8203	.8908	.8909	3.4567
	1.6523	.7893	.7932	.7867	.7605	3.2354
	1.9835	.8302	.9432	.7654	.6756	3.8950
	1.7634	.8564	.8342	.6956	.7432	4.2043
	1.6983	.8342	.7984	.7067	.7893	4.1023
	1.7523	.7954	.7783	.7654	.7798	3.9899
	1.8302	.7897	.7876	.7892	.8534	3.9089
	1.7983	.8901	.8576	.6754	.8756	4.0123
Class 2	0.2642	0.5645	0.3743	1.4726	0.3762	0.7985
	0.2523	0.5205	0.3521	1.5279	0.3543	0.8293
	0.2742	0.5321	0.3576	1.4782	0.3692	0.7342
	0.2621	0.5203	0.4201	1.7256	0.4120	0.7894
	0.2421	0.5098	0.3921	1.5179	0.3034	0.8103
	0.2342	0.4798	0.2982	1.5524	0.2982	0.7984
	0.2012	0.4731	0.3126	1.8209	0.3056	0.7999
	0.2231	0.4452	0.3762	1.8342	0.3654	0.7453
	0.1798	0.4201	0.4012	1.9098	0.3542	0.8254
	0.1823	0.4302	0.3433	1.9982	0.3672	0.8785

Class1 Of Mangoes Is For Smooth Surface Of Image Representing Healthy Mango Also And Class2 Is For Rough Surface Mangoes Representing Unhealthy Mangoes.

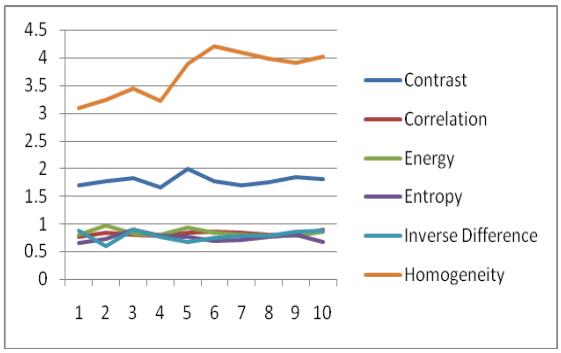


Fig 8(A): Texture Feature For Unhealthy Mango

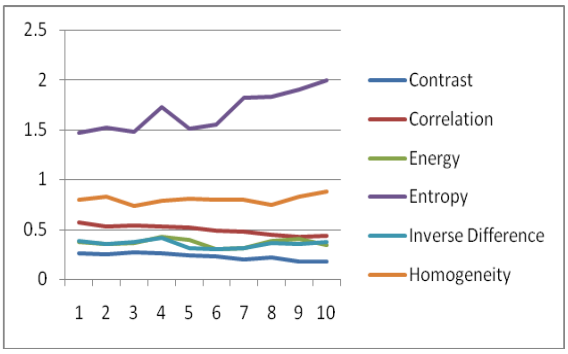


Fig 8(B): Texture Feature For Unhealthy Mango

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