Detection of Moisture Content of Fruits Using ANN

Shweta Kammar, Bhagat G. Inamdar and S.B. Kulkarni

Abstract--- *Percentage of moisture is an essential quality factor to detect the freshness of the fruit. Moisture Content (MC) has real impact on the mass of fruit. Proposed method is used to get texture parameters that imply the fruit's density. The MC of a fruit can be measured using statistical approach. To measure this, few texture parameters are analyzed from different views. In this light, artificial neural network (ANN) is used to get the loss moisture content as an error by considering the determined texture parameters as input. ANN estimates the moisture content of fruit with higher accuracy.*

Keywords--- *MC-Moisture Content, ANN-Artificial neural network, freshness.*

I. Introduction

CHECKING the moisture content of fruits is obvious and higher the moisture content in the fruit results in better quality. Moisture content of all variety of fruit has 80-95% of its whole weight. This implies that fruit is fresh if it has moisture in greater quantity. Extreme loss in MC results in loss of weight, in turn makes the fruits surface to dry up. Moisture content is estimated with statistical approach as one of the texture analysis based method to identify the surface parameters. Smoothness, variance, contrast, dissimilarity, entropy, uniformity are the surface information of the fruit image known as texture analysis parameters. This approach is used to specify texture of fruit images by converting images into gray level co-occurrence matrix.

Texture analysis parameters are taken as input to the neural network; which in turn the loss in the moisture content is estimated. Artificial neural network (ANN) is the best method to detect the moisture content of fruits with respect to days. ANN trains input and output to measure the loss moisture content as an error of predicted value to the actual value.

II. Literature Review

The moisture content of fruit is the main feature to identify the quality of the fruit. Contour imaging and ANN (Harker FR, 2008) is used to recognize the damaged apples. Golden and red apples are analyzed to differentiate variety of damaged fruits .ANN's are used for recognizing new to old fruits over a period of time to analyze the quality standards. Using this technique, achieved the accuracy from 60-90% for different apple bruises and identified the difference between new apples to older one. Smoothness, resolvable contented and sweetness is the real quality factors in the fruits marketing for sailing purpose.

Regular method is used to find smoothness, sweetness and resolvable contents of the fruit. Near infrared (NIR) and lightening system (Lu, 2003) is used to analyze the texture parameters of fruits without an impact on the fruit surface .Wavelength of the light to capture the image is very important factor to get the parameters of fruit more accurately. In this light, different wavelength is tested for the experimentation. Neural network is also applied to identify the internal quality of the fruits. Assessing the maturity of the apples, scattering and multispectral images is used (Noh HK, 2007).Test is carried out to verify the maturity of the fruit with different methods. These methods are used to recognize quality of apples without impact on the mass of the fruit. Predicting by neural networks with individual parameters has always lesser in correlation than that of using reflectance model. Moisture content of fruit is also one of the consumer needed feature to buy in the fruits marketing.

Changes in surface structure of a fruit over a period of time, is used to evaluate loss of moisture content. Identification of quality in eating the fruits is checked with long term schedule. Different methods are used to estimate the changes in the banana slice during drying procedure at various temperatures (Romano G, 2008). In this procedure, the banana color turns into brown with respect to days. Image processing is used to specify the changes in the color of banana slice after drying with temperature.

This method shows that there is a change in the moisture content of banana slices. It proves that moisture content is not only important factor for analyzing the quality of fruit, but also in scarp drying method.

Some sensors are utilized for monitoring the moisture content of rice during drying process (Chung JH, Verma LR, 1991). As well, black and white cameras are used to measure the moisture content in the cotton (JA, 1995) with some silicon sensor chips. Apple classification has been taken based on surface bruises using neural network and image processing methods (Shahin MA, 2002).Prediction of moisture loss of apple is observed using the simulations and practical usages in the postharvest technology (Veraverbeke EA, 2003).

III. Proposed Work

Detecting the moisture content of fruits using ANN is simpler than that of other methods. Regular method uses complicated procedures to estimate the moisture content of fruits as well as that consumes more time to detect fruits

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freshness. In this proposed system, number of images of a fruit is passed as input to the proposed system to analyze the moisture quantity. Once the images have been imported, texture parameters of images are measured through the statistical approach. Texture such as contrast, correlation, dissimilarity, variance, energy, entropy, homogeneity, maximum probability, average and smoothness are the parameters of a fruit surface which can be determined by the image processing method. Loss in the moisture content can be measured more accurately with the help of neural network technology by applying the texture parameters of the fruit surface as the inputs to it. This loss in the moisture content is an error for actual value to the predicted value.

A. Image Acquisition of Fruits

To capture images digital camera is used. For this proposed work, we have taken images of an apple with different views . As well as captured images ranges from fresh apple to old apples till 25 days respectively.

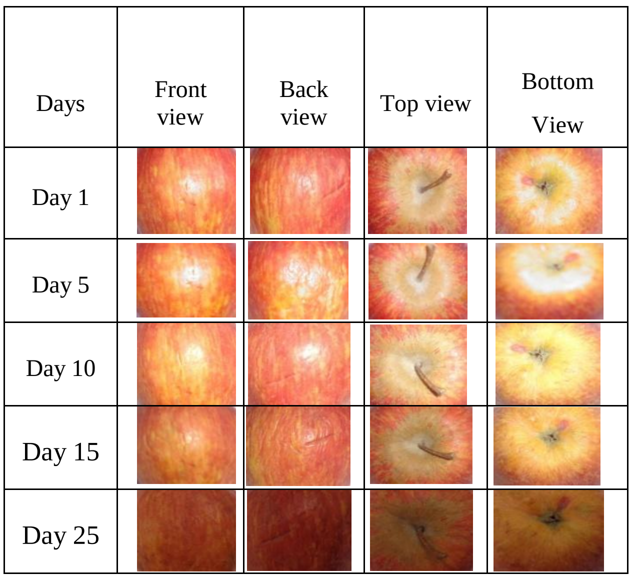

Figure 1:Apple Images with Respect to Days

B. Methods

Three methods are used to compare the moisture content of the fruit. In the first method, moisture content of fruit is measured using hot oven test method. The second method, i.e proposed method, detects the moisture content of fruits using electrical method. Third method is also proposed to detect the moisture content of fruits using ANN.

a) Regular Method to Obtain Moisture Content of Fruit

In regular method, the moisture content of fruit is measured by following procedure,

1. Cut the fruit vertically into 8 equal slices with peel.
2. One slice is taken and then cut into many small pieces.
3. Take empty dish (M) and weigh it.
4. Spread that one slice of fruit equally on the bottom of dish and weigh it (M1).
5. Keep this dish with sample in hot air oven at 100 Degree Celsius for 2 hours.
6. After 2 hours take dish out from hot air oven and cool it.
7. Determine weight of dish with dried material (M2).
8. Calculate Moisture Content (%) by weight as,

$$\text{Moisture Content } \% = [(M1 - M2)(M1 - M)] \times 10$$

The table describes the percentage of moisture content calculated using regular method shown in below Table 3.2

Table 1: Experiment on Hot Oven Test Method

Material	*Weights in gram*
Apple fruit	132
Empty dish(M)	128
Dish with apple Before drying(M1)	260
dish with apple after drying(M2)	152
Moisture content %	$[(M1 - M2) \div (M1 - M)] \times 100\%$ =[(260-152)÷(260-128)]×100%=81.8%

b) Electrical Method to Detect the Freshness of Fruits

Here, moisture content can be analyzed by current flowing through the fruits. With the idea of water conducts the current. Electrical method is experimented as follows,

1. Take the apparatus as DC power supply (0-12v), LED, single stand wires and fruit as an example, apple as shown in figure 3.2.
2. Connect wires as per the figure 3.2 with the correct polarities.
3. Connect the fruit directly by inserting wire into the fruit.
4. Observe the current conducting in the fruit with the help of LED glow in the electrical circuit.
5. Record the voltage values when current conducts in the fruit apple.

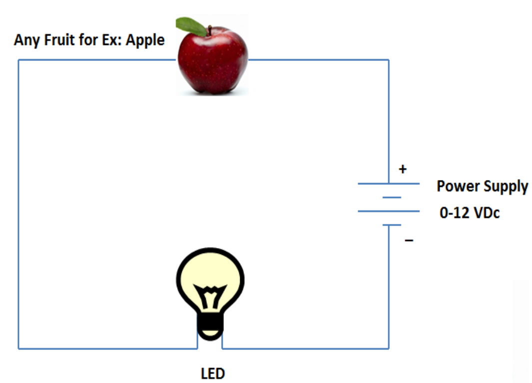

Figure 2: Electrical Circuits to Verify Freshness of the Fruit

All values of the fruit are observed from day 1 to 25.the circuit is made as shown in diagram.0-12V is applied through the circuit Voltage. Verify the LED glow (ON state) which indicates current flowing through the fruit. If LED turns ON by potential voltage apply then it shows moisture content present in the fruit. Observation is recorded against potential voltage, weight of the sample fruit over a period of days to measure of the freshness as shown in the table below.

Table 2:Apple Conducts Current at Voltages with Days

Days	*Voltages (0-12V)*	*Apple weight (grams)*
Day 1	2v	139
Day 2	3v	135
Day 4	3v	131
Day 6	4v	128
Day 8	4v	122
Day 10	5v	117
Day 12	5v	110
Day 14	6v	114
Day 16	7v	107
Day 18	8v	98
Day 20	8v	90
Day 22	10v	81
Day 24	10v	70
Day 26	11v	55
Day 28	12v	43

The above table shows the voltage records at which current conducts in the specified apple fruit. Current conducts in the apple with days by applying voltages.

The supply of more voltage over a period of time indicate more pressure is required to pass the current through the sample fruit, which is a result of loss in the moisture content of the fruit. The sample fruit at Day 1 conducts current at 2V and the same sample at day 25 conducts current at 12V. This implies that fruit (apple) losing its moisture content day by day. Hence the loss of moisture content the fruit is proportionally equal to decrease in the weight of the fruit over a given period.

C. Functions used in Image Processing Method and ANN

Image acquisition is done as per different views of fruits to detect the moisture content of fruits with days. Extract the surface of the fruits at four views (front, back, top and bottom) by using crop tool. Extracted images to be saved by specifying the dates to identify the fresh and old fruits .Once the extraction of fruit surface has been taken then it requires to undergo the statistical approach by converting images into gray level co-occurrence matrix to calculate the image texture parameters .These texture parameters are contrast, correlation, dissimilarity, uniformity, entropy, homogeneity, maximum probability, variance, average, smoothness etc. These are used to identify the surface information of the fruits. Average value of 4 views of fruit has taken as an input to the ANN where n1, n2, n3 are neurons with 5000 epochs by using back prorogation learning algorithms. Dissimilarity in the inputs is predicted based on empirical method. If the difference between two parameters is greater than 50% on each paired parameter then the results into 1 or 0.Artificial Neural Network is used inputs from the determined texture parameters with empirical based method to estimate the loss moisture content of fruits of predicted value to the actual value.

4 Algorithms

To extract texture parameters of fruit image, following steps are taken :

1. Read the extracted surface image with any size.
2. Convert the rgb image to gray scale image
3. Create gray level co-occurrence matrix as
   glcm= graycomatrix(I,'Offset',[])
4. Repeat for each k=1 to size_glcm
5. Normalize the matrix
   Pij = glcm(:,:,k)./glcm_sum
6. Calculate each of the texture parameters by using the formulae
   $Contrast=\sum\sum(abs((i-j)^2) \times Pij)$
   $Dissimilarity=\sum\sum(abs(i-j) \times Pij)$
   $Energy=\sum\sum(Pij)^2$
   $Entropy=\sum\sum((Pij \times log(Pij+))$
   $Homogeneity=\sum\sum(abs(i-j) \times Pij)$
   $Dissimilarity=\sum\sum(Pij/(1+abs(i-j)))$
   Variance= ∑∑ (Pij× ((j-glcm_mean) ^2))
   $Maximum\ probability=max(Pij(:))$
   Smoothness=1-[1÷ (1+∑ (∑ (Pij× ((j-glcm_mean)^2))))]
   $Sum\ of\ average= \sum((ii+1) \times p\_xplusy)$
7. Display the calculated texture parameters
8. End repeat

Neural network algorithm.

1. Initialize user specified value such as number of neurons and epochs.
2. Activate the back-propagation neural network by applying desired inputs and outputs
3. Load XOR data as train input and train output.
4. Check same number of patterns in each input with train output.
5. Standardize the data to mean=0 and standard deviation=1
6. Read number of patterns and inputs
7. Add a bias as an input
8. Add button for early stopping and resetting weights.
9. Set initial random weights
10. For each epoch
11. Get the learning rate from the slider.
12. Loop through the patterns, selecting randomly.
13. For each j = 1 to number of patterns
14. Select a random pattern and set the current pattern.
15. End for
16. Calculate the current error for this pattern
17. Adjust weight hidden – output and input-hidden.
18. End for
19. Plot overall network error at end of each epoch
20. if err(iteration) < 0.001 then display error
21. end if
22. Display actual, predicted& error

IV. EXPERIMENTAL RESULTS

Measured all texture parameters of an apple on day 1 by statistical approach are shown in Table 3 and P1 to P10 are the texture parameters of all the views of an apple.

Table 3:Experimented Texture Parameter Values of Fresh Apple

Parameter	Apple Views				Average of all 4-views	Parameter Combination
	Front	Back	Top	Bottom		
P1=contrast	0.3586	0.4108	0.3286	0.3487	0.361675	I1
P2=correlation	0.8653	0.6406	0.6873	0.7417	0.733725	
P3=dissimilarity	0.3478	0.3975	0.3145	0.3267	0.346625	I2
P4=energy	0.1509	0.1954	0.2283	0.1966	0.1928	
P5=homogeneity	0.8279	0.8035	0.8449	0.8402	0.829125	I3
P6=maximum probability	0.3079	0.3713	0.4001	0.3485	0.35695	
P7=variance	38.4379	34.9046	46.0087	49.4048	42.189	I4
P8=sum of average	12.3042	11.7882	13.5262	13.9969	12.903875	
P9=smoothness	0.9746	0.9721	0.9787	0.9802	0.9764	I5
P10=Entropy	2.2942	1.9852	1.8448	1.9538	2.0195	

Table 4: XOR Combination Inputs to Neural Network for Fresh Apple

XOR combinations as inputs	Parameter	Value	Parameter	Value
I1	Contrast	0.361675	Correlation	0.733725
I2	Dissimilarity	0.346625	Energy	0.1928
I3	Homogeneity	0.829125	Maximum probability	0.35695
I4	Variance	42.189	Sum of average:	12.903875
I5	Smoothness	0.9764	Entropy	2.0195

Table 5: Estimated Error Records of an Apple on Day 1

XOR inputs	Actual value	Predicted value	Error	Actual values average	Predicted values Average	Error average
0.361675,0.733725	1	0.3876	-0.6124	0.8	0.58142	-0.21858
0.346625,0.1928	0	0.2651	0.2651			
0.829125,0.35695	1	0.3531	-0.6469			
42.189,12.903875	1	0.9937	-0.0063			
0.9764,2.0195	1	0.9076	-0.0924			

Loss moisture content is estimated as an error of an actual value to the predicted value more precisely for the texture parameters of the surface image of the acquired fruits in Table 5. As the days goes, there is a loss of moisture content in the fruits. Experimented results shows clear idea that fruits moisture content gets loss with days using image processing method.Figure 3 neural networks is used to detect loss moisture content error from predicted value to the actual value.

This neural network takes inputs p1-p10 texture parameters and move through the hidden layer with 3 neurons to produce 5 outputs I1-I5 as mentioned in the Table 2.

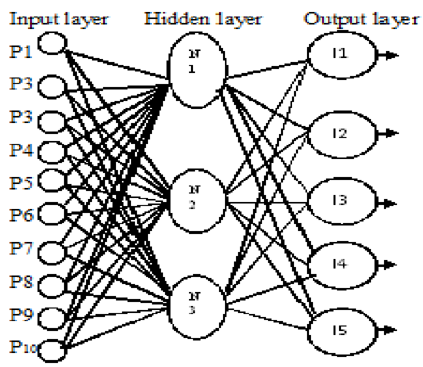

Figure 3:Neural Network

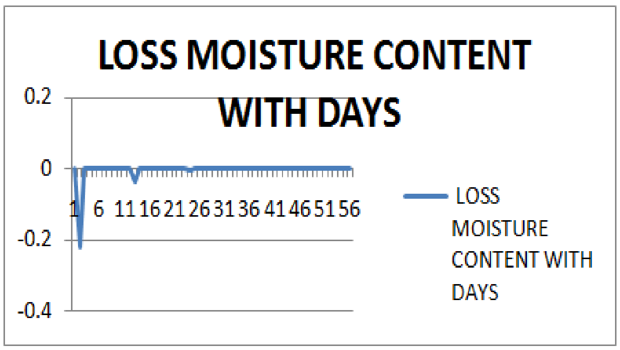

Figure 4:Graph Analyses of Loss Moisture Content of Fruit for Day 1 to day 25.

V. CONCLUSION

The proposed work is simpler and most effective than that of other test method. Detection of moisture content of fruits using ANN gives result very quickly and more accurately. This proposed system determines the moisture content of fruits using Image Processing Method and ANN. Also checking the quality of fruits by testing the Lost Moisture Content of variety of fruits. Result illustratesthat as the day's moves, there is increase in the loss of moisture content of fruit.

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