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FRUIT FLY ALGORITHM FOR ESTIMATION OF QUALITY RIPENINGOF FRUITS

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ABSTRACT

Ripening is the progression by which fruits and vegetables attain their smart taste, brilliance, colour, edible nature and other textural properties. Ripening is related with variation in worki.e. varyfrom starch to sugar. A scheme for estimating ethylene (C_2H_4 in ppm) stage employing soft sensor is the purpose of this work. The projected method relies on the color of the fruit or the vegetable which denotes the various stages of ripening which in turn indicates the amount of ethylene gas necessary for the ripening method. Apples, pears, bananas, and mangoes are some of the fruits that release ethylene while ripening. Ethylene is responsible for varying in texture, softening, color, and other processes anxious with ripening. The evaluation of ethylene concentration released from the fruits indicates the stage of fruit ripening and measurement of ethylene is predictable during the post gather of the fruits and also throughout the haulage of the fruits in order to avoid over ripening. The capability of ethylene required for fruit ripening is carried out using a Feed Forward Neural Network (FFNN) trained with Back Propagation Algorithm (BPA) also required to sort out the type of ripening. Fruits are also ripened by artificial ripening methods which are not supportable for consumption. The intensity values in color images of the fruits are used for characteristic mining which is then used as inputs to train the FFNN. In order to attain high exactitude and sensitivity, various provisions have to be taken in order to eradicate hindrance effects. These comprise, for instance, the compensation of temperature or pressure variations in the gas, which may have a control on the ripening process. The accessible techniques for measurement of ethylene gas are chromatographs, Fourier Transform, infrared spectroscopy and electrochemical sensors which are laboratory based logical methods and are pricey. To overcome the limitations of the accessiblelogical techniques a simple and cost valuable soft sensor desires to be developed.

Keywords: Artificial Intelligence, Back Propagation Algorithm, Ethylene gas emission and Characteristic extraction.

1. INTRODUCTION

Ripening is a progression which adds colour, taste, flavor, aroma and appearance for the fruits and vegetables becomefeasible. They are alienated as climacteric and non-climactericfor ripening of the fruits. Climacteric fruits are defined as fruits that enter 'climacteric phase' after yield *i.e*. they prolong to ripen. During the ripening process the fruits release ethylene along with increased rate of respiration [1]. Ripe fruits are malleable and feeble and usually cannot bear rigors of transport and frequent handling. These fruits are harvested solid and green, but fully grown-up and are ripened near consumption areas. Small quantify of ethylene is used to persuade ripening process under prescribed conditions of temperature and moisture. They include mango, guava, fig, apricot, banana, kiwi, apple, plum, pear and passion fruit [2]. The other category is the non-climacteric fruits once harvested do not grown-up further. Non climacteric fruits produce very small quantity of ethylene and do not respond to ethylene treatment. There is no characteristic increased rate of respiration or production of carbon dioxide. They consist of orange, grapes, litchi, watermelon, blackberry etc [3].

2. EXISTING METHODS FOR RIPENING OF FRUITS BY SURVEY IN PRACTICE

Lack of easier and rapid methods for constant ripening pose a key difficulty in the fruit industry. Approximately all methods of ripening, either predictable or the modern chemical methods, come with their own behavior. There are quite a few easy technologies and methods existing today for farmers for good ripening. In general, the number of days taken for edible ripening varies for different fruits and prevailing climatic conditions. They consist of

1. Mango ripening in an air stiff rice container. This is a usual process of ripening but not valid on large scale.
2. Smoking inside smoke chambers using acetylene gas.
3. Layers of paddy shell or wheat straw as a naturalripening medium.
4. Immerse immature fruits in 0.1 per cent ethrel solution, clean dry and extend them over a newspaper or clean cloth without touching each other.
5. 10 ml of ethrel and 2 gm of sodium hydroxide pellets are added in five litres of water in a broad mouthed container placed within the ripening chamber near the fruits and the room is preserved air tight.
6. Fruit ripening by means of calcium carbideas aartifical ripening agent.

Prevention of Food Adulteration (PoFA) has forced stringent rules to discard the usage of calcium carbide as it is dissolved in water, produces acetylene which acts as an artificial ripening cause. Acetylene is found to affect the nervous system by reducing oxygen supply to brain. Arsenic and phosphorus are noxious and exposure may cause severe health hazards. Hence from this survey it is recognizedthat ,The only safe and worldwide conventional method is using ethylene, which is a natural hormone for ripening when done under controlled temperature and relative humidity conditions and pressure can be used for ripening process which is considered as a secure process.

3. RIPENING PROCESS USING ETHYLENE GAS

Ethylene is aninnate hormone and does not stimulate any side effects to the human community when consumed in large quantities over long periods [4]. This de-greening agent is capable of converting the chlorophyll responsible for the green colour of the fruits to yellow colour which indicates the carotenoids when applied under optimal ripening conditions [5]. The optimal conditions are listed in Table 1

Table 1. Finest Ripening Conditions

S.No	Substantial Parameters	Finest Range
1.	Temperature	18 ^{o}Cto 25^{o}C
2.	Dampness	90 to 95%
3.	Ethylene concentration	10 to 100 ppm
4.	Extent of Exposure	24 to 74 hours depending on fruit type and stage of maturity
5.	Air flow	Sufficient to ensure distribution of ethylene
6.	Aeration	Require adequate air exchange in order to prevent accumulation of O_2’ which reduces effectiveness of C_2H_4.

Structure chosen for applying ethylene depends on cost, viability and security factors. Diluted ethylene gas mix is securer than using pure ethylene, which is volatile and also combustible at 3% or higher concentration [6]. Fruits to be fully grown are placed in a hermetically preserved ripening room maintained at a constant temperature (18-21^{o}C for most fruits, but 29-31^{o}C in mango). The most favorable storage and ripening temperatures for various fruits are given in Table 2.

Table 2.Finest storage and ripening temperatures for various fruits

S.No	Name of the Fruit	Ethylene Concentration (ppm)	Ethylene exposure time (hrs)	Ripening temperature ^oC	Storage Temperature ^oC
1.	Avocado	10-100	12-48	15-18	4.4-13
2.	Banana	100-150	24	15-18	13-14
3.	Honey dew melon	100-150	18-24	20-25	7-10
4.	Kiwifruit	10-100	12-24	0-20	0.5-0
5.	Mango	100-150	12-24	20-22	13-14
6.	Orange degreening	1-10	24-72	20-22	5-9
7.	Stone fruit	10-100	12-72	13-25	-0.5-0

There are two structures of revealing fruits to ethylene.
1.Trickle method involves trickling ethylene gas into room so as to sustain a concentration of 10 ul per litre, naturally for a period of 24 hours. Room is then ventilated after 24 hours to avoid carbon dioxide exceeding 1% concentration, which would delay ripening process. Forced-air ripening affords more uniform temperature and ethylene concentration throughout ripening room.
2. Ripening can also be commenced using ethylene generated by passing ethanol over a bed of activated alumina. This structure is securer than using pure ethylene gas. Care should be taken to ventilate the ripening rooms daily so as to ensure that Carbon-di-oxide (CO_2) levels do not exceed 1%.

4. CHALLEGES IN RIPENING PROCESS

Ethylene gas is introduced into ripening rooms from high-pressure cylinders via flow-meters or by ethylene generators,whichtransform alcohol into ethylene via a heated metal catalyst. Controlling the rate of ripening effectively for fruits ripening is a great deal to meet the consumer demands, which involves considerable practice.
The various dynamics such as initial fruit maturity, temperature, relative humidity, air flow, as well as ethylene and carbon dioxide concentrations within the ripening room may all affect the rate of ripening. Carbon dioxide, as a by-product of ripening; process on excess levels (>5%) will rotten the fruits and vegetables. Hence anvaluable method for measurement of the ethylene gas as well as carbon dioxide from the color of the fruits is projected.

5. PROJECTED METHOD FOR FRUIT RIPENING PROCESS

The ripening is a process reliant on step by step color change of the fruit, initially from green to yellow color stands as a base for this work. Color image processing finds application in this area to evaluate the ethylene and CO_2 gas levels with respect to the color of the fruit.

The video of the fruits image is attained by using the infra red camera. The video is changed into frames using video splitter and these frames are further analyzed. The characteristics are extracted from the images captured and these characteristics are used for C_2H_4 and CO_2 gases estimation as discussed in [1]. The major steps involved in the projected ripening quality monitoring system as depicted in Figure 1 includes the following

1. Infrared camera by means of servo motor mechanism.
2. CCTV set up is placed in the control room.
3. TV tuner is installed for transferring the video from the CRT monitor on to the PC.

4. Image processing packages are stacked in the laptop connected to the TV tuner.
5. The video file which is split up into frames for further scrutiny.
6. Image processing algorithms for analyzing the constituents of the images.
7. Intelligent control scheme to monitor and estimate the ripening process.
8. The validation of the developed algorithms.

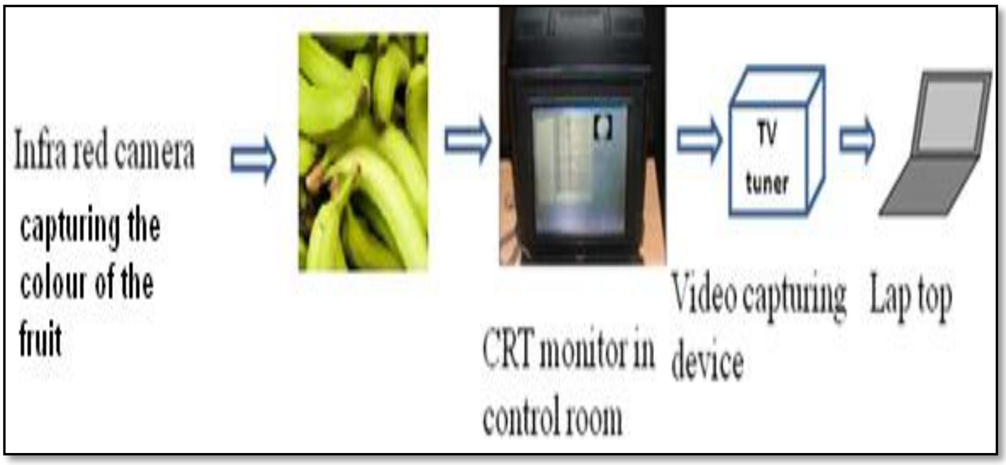


Figure 1. Schematic diagram of the projected fruit ripening monitoring system

6. OBJECTIVE OF THE PROJECTED METHOD

The primary objective of this workis todevelop a fruit ripening quality monitoring system using fruit image scrutiny by colour image processing in the container.According to the brightness value of the image pixels, the ripening characteristic parameters are picked up from the images. The online monitoring of ripening quality, C_2H_4 and CO_2 gas estimation using intelligent image processing technique thereby offers dynamic adjustment of C_2H_4 flow rate so as to ensure effective ripening process.

7. RESULTS AND DISCUSSION

The results for various conventional and intelligent schemes for monitoring fruit ripening process are discussed elaborately in this chapter. The images are preprocessed to ensure that it should be noise free and the desired images are used for scrutiny and monitoring purposes alone. The schematic for the projected concept is shown in Figure 2.

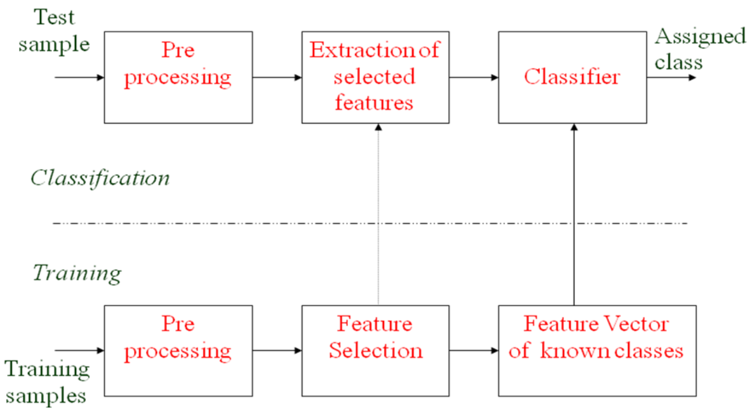
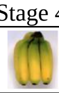
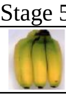
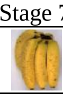


Figure 2.Methodology for Fruit ripening process using Image processing

The fruit images are captured by the infra red camera asa sensor placed at the top corner of the room with a servomotor mechanism for changing the direction of the camera. The infra red camera is of Sony make. The video acquired is converted to frames using video splitter software. The images acquired are preprocessed, analyzed before feature extraction and classification. The collected data is recorded in Table 3.

Table 3. Ripening parameters corresponding to various fruits

Ripening parameters	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6	Stage 7
Images of Banana fruit							
Images of Mango fruit						**NA**	**NA**
Ethylene conc.(ppm) for Banana fruit	140-150	130-140	120-130	115-120	110-115	110-100	100 -10
Ethylene conc.(ppm) for Mango fruit	140-150	130-140	120-130	110-120	110-100	**NA**	**NA**
Ethylene exposure time (hrs) for Banana fruit	24	24	24	12	12	6	6
Ethylene exposure time (hrs) for Mango fruit	24	24	24	12	12	**NA**	**NA**
Ripening temp. ^{o}C for Banana fruit	15-15.25	15.25-15.5	15.5-16.25	16.25-16.5	16.5-17.25	17.25-17.5	17.5-18
Ripening temp. ^{o}C for Mango fruit	22	22	22	21	20	**NA**	**NA**

The preprocessing includes dithering,filtering and edge detection. The filtering removes noise so that the noise free images can be used for additional analysis and the edge detection is carried out to extract the region of interest which in turn determines the characteristics to be extracted.

Image approximation is done to decrease the number of colors in an image; the ensuing image might look mediocre to the original, because some of the colors are vanished. Dithering is performed to amplify the visible number of colors in the output image and also changes the colors of the pixels in thevicinity so that the normal color in each neighborhood approximates the unique RGB color.The output for dithering and filtering for Banana is shown in figure 3.

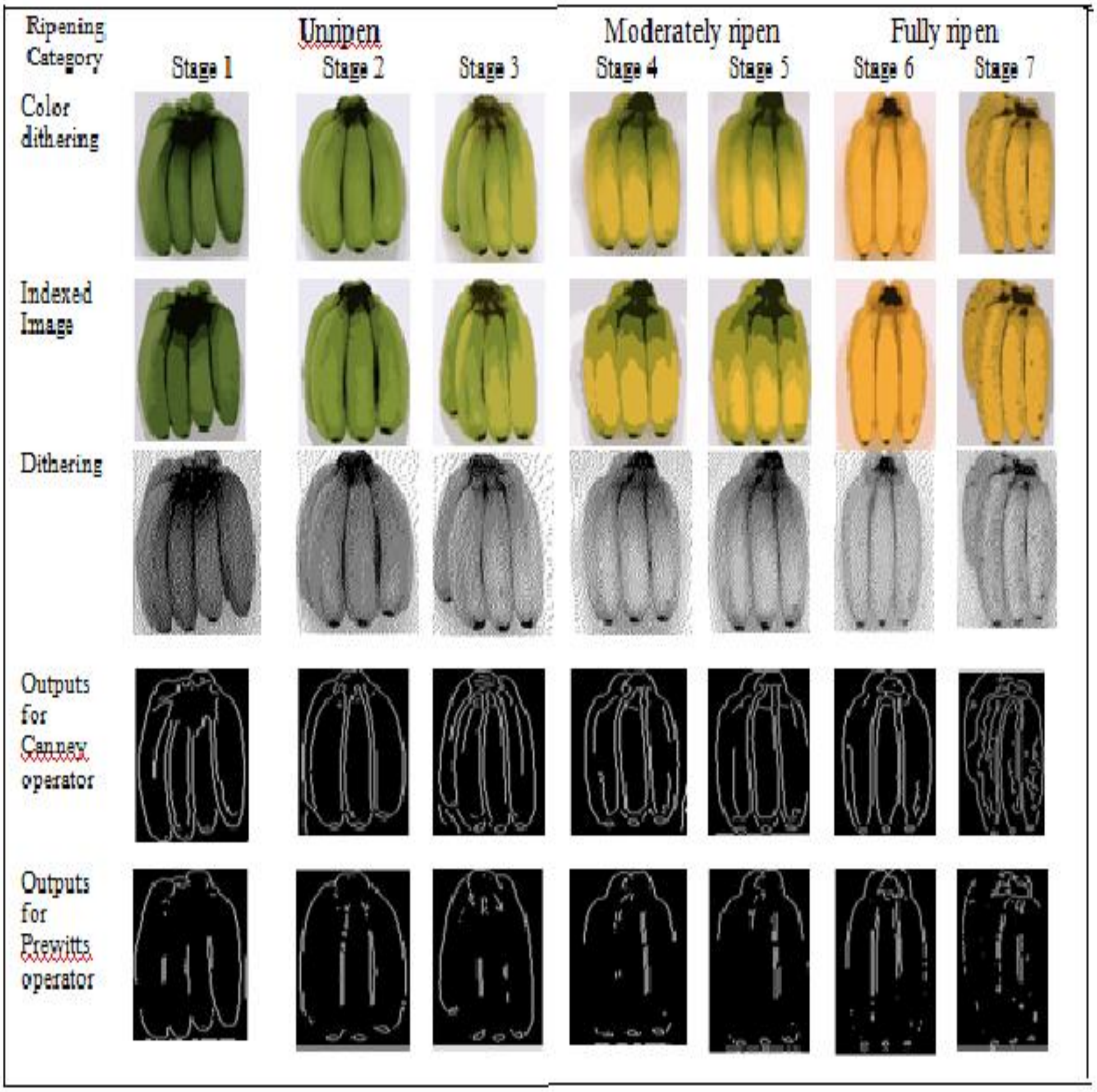


Figure 3.Output for Dithering and Filtering

The output for dithering and filtering for Mango is shown in figure 3

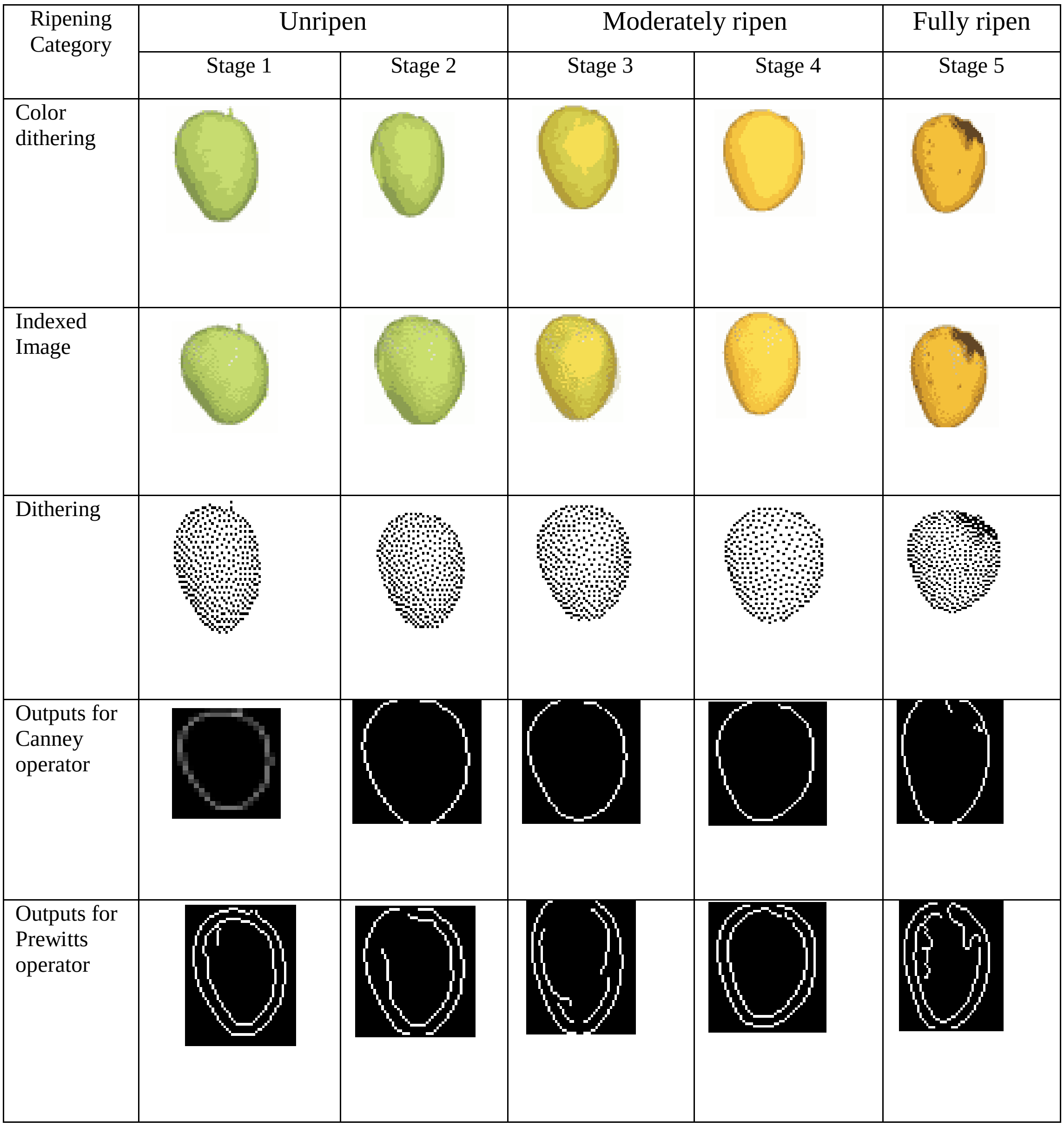
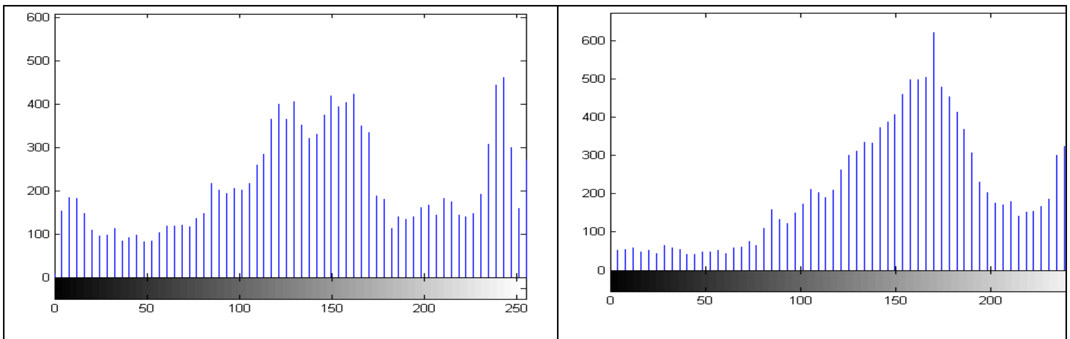
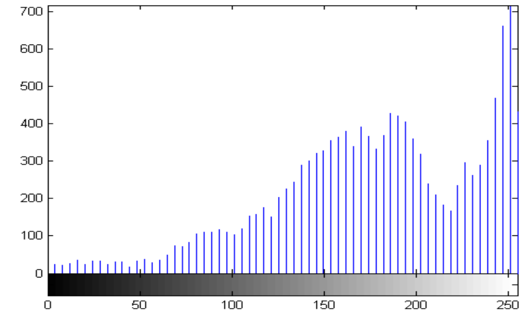


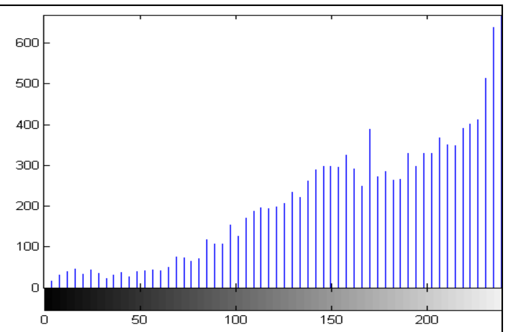
Figure 3.Output for Dithering and Filtering



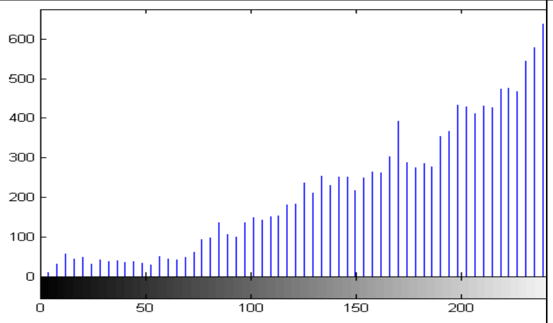
(a). Stage 1 (b). Stage 2



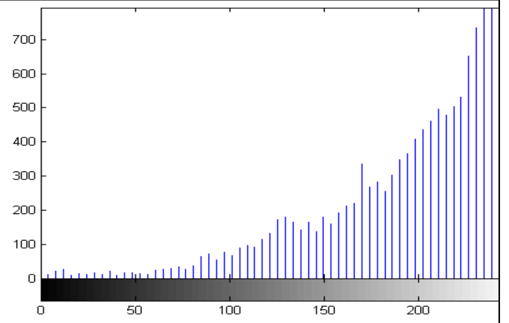
(c). Stage 3



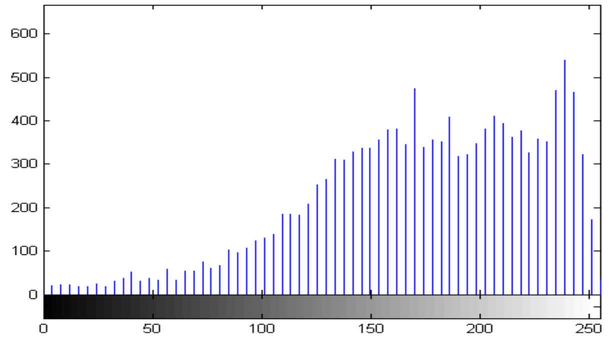
(d). Stage 4



(e). Stage 5

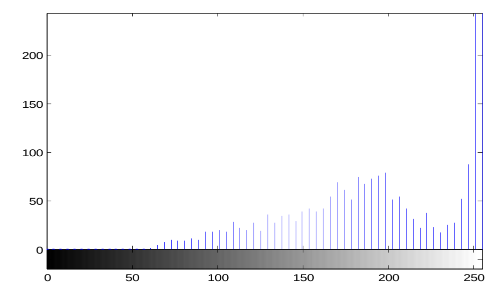


(f). Stage 6

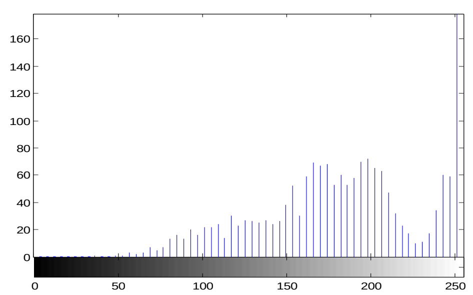


(g). Stage 7

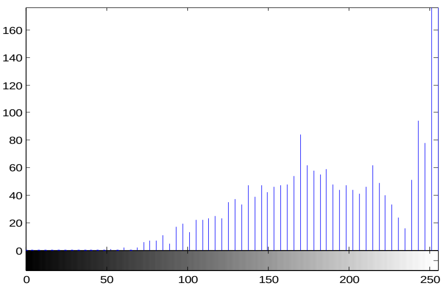
Figure 4. Histogram for Ripening process of Banana



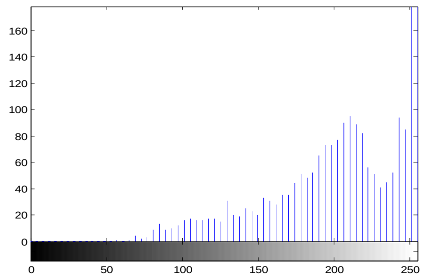
(a). Stage 1



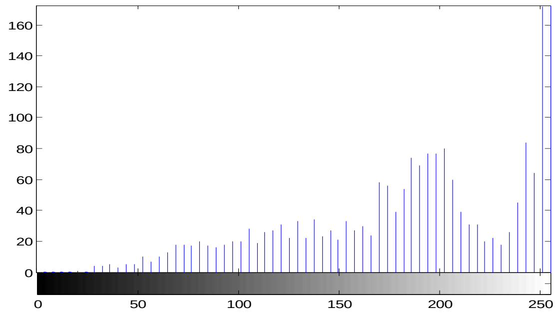
(b). Stage 2



(c). Stage 3



(d). Stage 4



(e). Stage 5

Figure 4. Histogram for Ripening process of Mango

Figure 4 denotes the histogram which is the plot between the pixel strength and their frequency of occurrence. During the initial stages (from 1 to 3 stages denoted as Unripen) of ripening, the strength values lie between a minimum of 100 to a maximum of 175 which is totally green in colour (see Figure 4(a) to (c)).For the stages 4 and 5 (denoted as Moderately ripen) the maximum and minimum strength range is 175-225 (Figure 4(d) to (e)). These stages are partially green and yellowish. For the remaining 2 stages(denoted as Fully ripen) which is entirely yellowish; the strength values range from 175- 255 which is evident from Figure 4(f) to (h). This histogram analysis is done to verify that the colour variation facilitates the measurement and control of the ethylene gas supply which is used as the ripening agent.

The various features like mean, standard deviation, mode and variance are extracted from the images. The features represent the basic pattern that gets repeated in various directions to form an image. Hence by extracting the selective features the ripening state as well the amount of ethylene gas inside the ripening chamber can be calculated.

Table 4. Feature Extraction for Banana

S.No	Mean	StdDev	Mode	Median
1.	110.541	68.044	255	91
2.	140.89	59.907	244	125
3.	174.705	56.475	246	170
4.	187.24	55.931	255	206
5.	181.119	57.356	218	199
6.	231.265	35.707	246	245
7.	196.985	38.898	221	203

Table 4. Feature Extraction for Mango

S.No	Mean	StdDev	Mode	Median
1.	201.948	48.483	255	182
2.	195.823	47.657	255	177
3.	197.311	46.854	255	181
4.	205.218	40.925	255	187
5.	188.681	54.928	255	169

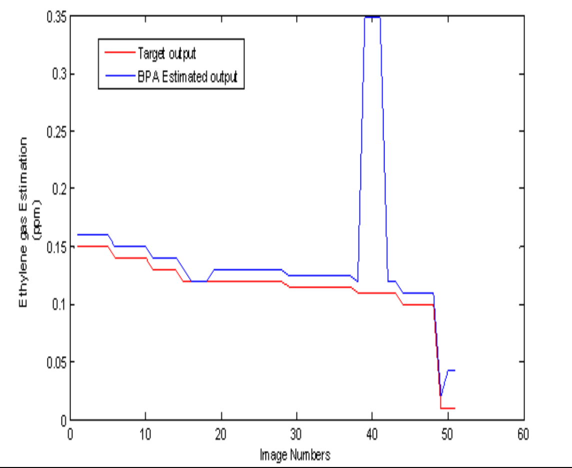
The evaluationwasdoneusingFeedForward (FF) architecture of trainedwith Back Propagation Algorithm (BPA). The FF Neural Network (NN) is constructed by highly interconnected processing units (nodes or neurons) which perform simple mathematical operations. Neural networks are characterized by their topologies, weight vectors and activation function which are used in the hidden layers and output layer. The topology refers to the number of hidden layers and connection between nodes in the hidden layers. The activation functions that can be used are sigmoid, hyperbolic,tangent and sine.

The network models can be static or dynamic. Static networks include single layer perceptrons and multilayer perceptrons. A perceptron or adaptive linear element (ADALINE) refers to a computing unit. This forms the fundamental building block for neural networks. The input to a perceptron is the summation of input pattern vectors by weight vectors. Information flows in a feed-forward manner from input layer to the output layer through hidden layers. The number of nodes in the input layer and output layer is fixed. It depends upon the number of input variables and the number of output variables in a pattern. In this work, there are seven input variables and one output variable. The number of nodes in a hidden layer is fixed by trial and error. In this application, the network parameters suchas the number of nodes in the hidden layers and the number of hidden layers are found by trial and error method. In most of the applications one hidden layer is adequate. As the name implies BPA the weight updation takes place in the reverse order i.e. from the output layer to input layer [7].

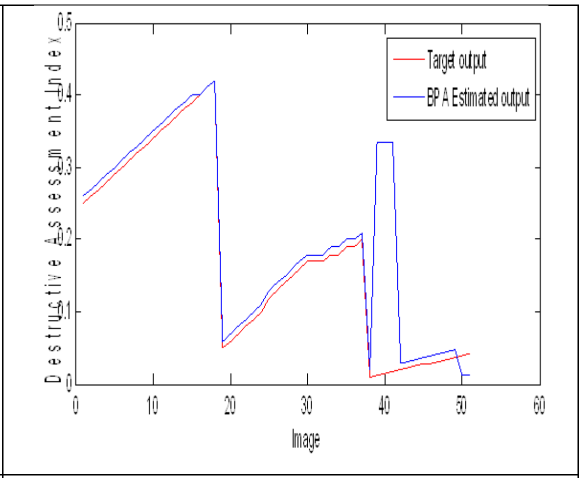
FFNN structure trainedwith BPA isused to identify the estimation of ethylenegas for ripeningprocessso as to prevent the fruits fromrotteningduring the process of de-greening. Emission of CO_2islikely to rotten the ripened fruits ratio and flametemperature. The featuresobtainedfrom the images are given as the inputs to the FFNN.Table 5 contains the values for various features extracted. The target is the value of the C_2H_4 gas concentration. The normalized values of the features are used for obtaining results from the various intelligent classifiers. For normalization each value of the feature divided by the maximum value of that feature is used as the formula so as reduce the computational complexity.

The inputs for FFNN trained with BPA require4 features as given in Table 5. A set of final weights are obtained by training with desired target value (C_2H_4gas concentration). Testing the projected algorithm to infer the ripening state and C_2H_4 gas concentration from the fruit image is done with final weights obtained after training to achieve feed forward control C_2H_4 gas concentration. The outputs of the FFNN trained with BPA are shown in Figure 5. Similarly the FFNN was trained and tested as discussed above. The Table 5 shows the network parameters with values prescribed for the objective function.

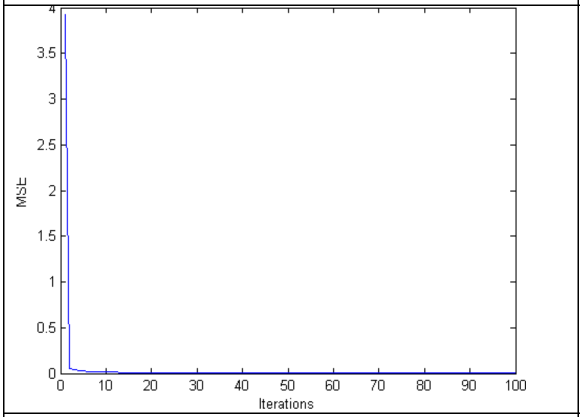
Validation of FFNN withfour features as input and one output is done. Table 5 given below shows the data relating to the fruit images collected at some other stage of time. The results in Table 6 support that intelligent estimation isvaluable for fruit ripening quality monitoring. The training and testing results are very close to the validation results. The precision and recall for all the three classes are shown in Table 7 below.



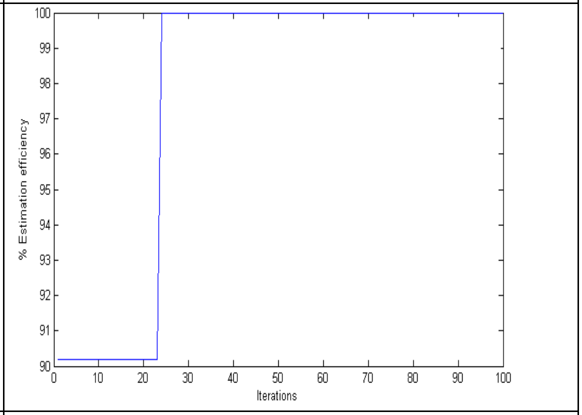
(a). Estimation of Ethylene gas by Feed Forward Architecture trained with BPA



(b). Estimation of DAI using BPA



(c). MSE Vs Iterations



(d). Estimation Efficiency

Figure 5. Training results for Feed Forward Architecture trained with BPA

Table 5. Network Parameters for training the ANN

S.No	Network Parameters	Values
1.	No. of nodes in the input layer	4
2.	No. of nodes in the hidden layer	3
3.	No. of nodes in the output layer	1
4.	No. of patterns for training	51
5.	No. of patterns for testing	51
6.	Mean Squared Error	0.0198
7.	Activation function	sigmoid
8.	Network Architecture	Feed Forward
9.	Algorithm used	BPA

8. GENETIC ALGORTHIM

Genetic algorithms are based on biological progress. Genetic algorithms can be used to explain a wide variety of problems. Given a problem a genetic algorithm generates a set of possible solutions and evaluates each in order to choose which solutions are fit for reproduction. If a particular solution is more fit then it will have more chances to generate new solutions. Finally we can find a real solution.

The genetic algorithm uses three main types of rules at each step to produce the next generation from the current population:

- *Selection rules* select the individuals, called *parents*, that contribute to the population at the next generation.
- *Crossover rules* combine two parents to form children for the next generation.
- *Mutation rules* apply random changes to individual parents to form children.

Artificial Intelligence (AI) is the study and creation of computer systems that can perceive reason and act. The primary aim of AI is to produce intelligent machines. The intelligence should be exhibited by thinking, making decisions, solving problems, more importantly by learning. AI is an interdisciplinary field that requiresfacts in computer science, linguistics, psychology, biology, philosophy and so on for serious research.Genetic algorithm is a kind of Artificial Intelligence which is used to train the neural network.

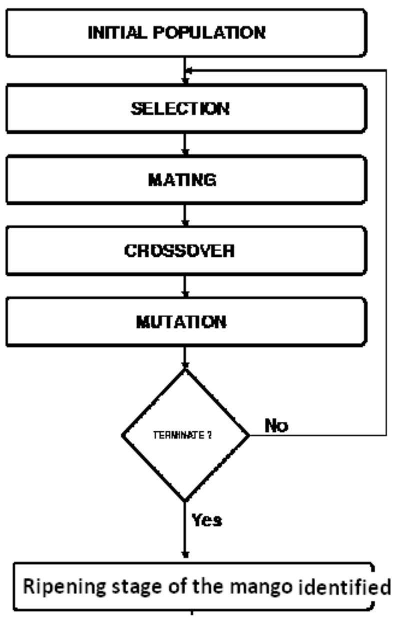


Figure6. Flowchart for Genetic algorithm

The extracted features are used for estimation by Genetic Algorithm. The Genetic Algorithm along with the extracted features is used for training the ANN. The close connection between the training and testing patterns in identification of mango ripening with respect to intensity is shown in Figure 7. Similarly the surface plot in Figure 8 shows the relation between the intensity and ripening stage. The estimation of Quality ripening process and generations is depicted in Figure 9.The improvement made in application side denotes that earlier a circuit with capacitance is used to generate ethylene gas for this purpose which is on other hand replaced by using a soft sensor.The parameters of GAis shown in Table 6.

TABLE 6. Parameters of GA

S.No	Parameters in GA	Parameter value
1.	No. of Generations	40
2.	Population size	150
3.	Fitness value	0.022
4.	Probability of mutation	0.1
5.	Type of cross over	Single point cross over
6.	No. of bits in cross over	8

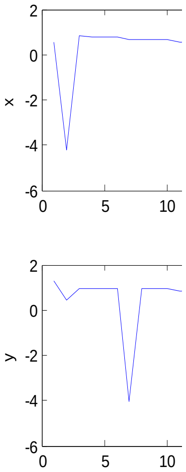


Figure7. Estimation of intensity values by GA in ripening stage identification

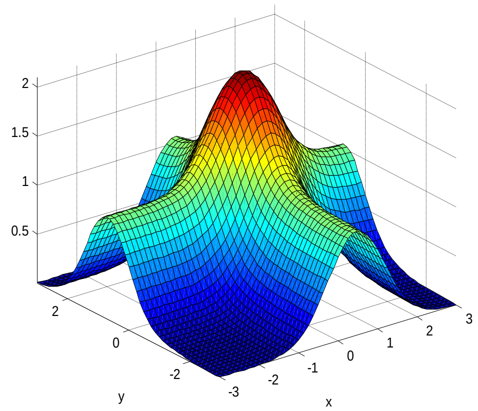


Figure8. Surface plot for Ripening stage

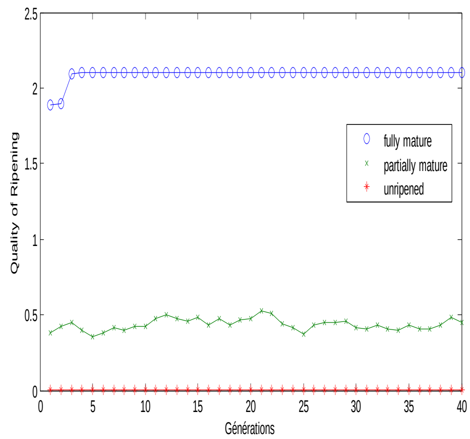


Figure9. Estimation of Quality ripening process by GA

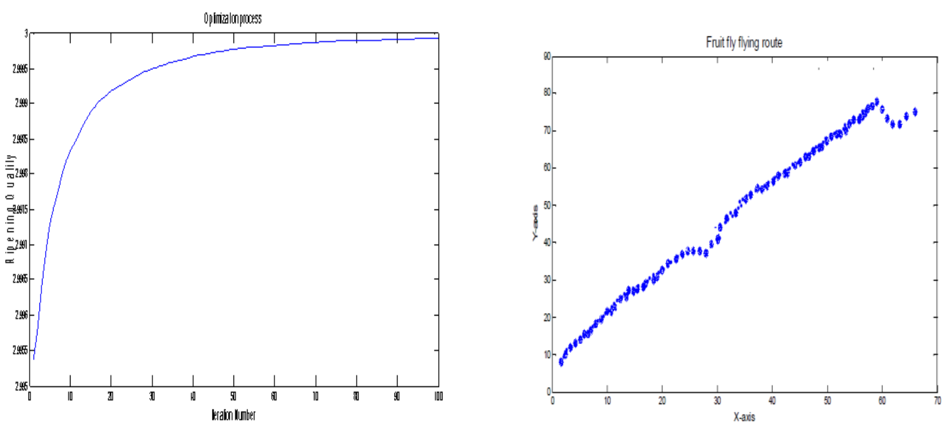


Figure 10. Results for fruit fly algorithm

Iteration Number

9. CONCLUSION

In this work, 102 images collected from the ripening room. The images are pre-processed and features are extracted. Training of FFNN using BPA is done with 51 images taken for unripen, moderately ripen and fully ripen so as to achieve the final output. Also other AI based methods like GA and FFA are incorporated. Testing and validation results shown in Table 7 indicate that maximum classification performance is obtained using FFA. Classification performance can be improved by further pre-processing of the acquired images. Depending on the quality of ripening; corresponding to the colour of the fruit images necessary action is taken to increase or decrease the C_2H_4 gas supply so as to ensure complete efficient ripening process. The inferred parameters can be displayed through the cloud service for anytime monitoring and control providing a cost valuable solution. To conclude with there is a further scale to extend the work by considering the spectrum of the images.

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Table 7. Comparison of performance criteria for testing and validation

Comparison Testing/Validatior	Class 1		Class 2		Class 3	
	Precision	Recall	Precision	Recall	Precision	Recall
Testing results	1	1	0.894	1	0.85	1
Validation resu	1	1	0.8358	1	0.8	1

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