DEGRADATION ANALYSIS OF BANANA USING COMPARATIVE APPROACH

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This Report Presented in Partial Fulfillment of the Requirements for the Degree of Bachelor of Science in Computer Science and Engineering.

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APPROVAL

This Project titled "DEGRADATION ANALYSIS OF BANANA USING COMPARATIVE APPROACH", submitted by M. Raki Billah (161-15-6803), Sayed Ahmed (161-15-7041) and Rabeya Kamal Surovi (153-15-6578) to the Department of Computer Science and Engineering, Daffodil International University has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of B.Sc. in Computer Science and Engineering and approved as to its style and contents. The presentation has been held on 07.12.2019.

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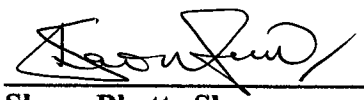

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We hereby declare that, this project has been done by us under the dynamic supervision of **Dr. Syed Akhter Hossain, Professor and Head, Department of CSE** Daffodil International University. We also declare that neither this project nor any part of this project has been submitted elsewhere for award of any degree or diploma.

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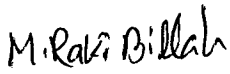

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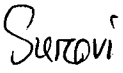

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ABSTRACT

In recent times, the considerations of improving the product and food quality are turned into a big concern. Continuous uses of chemical, formalin and so many preservatives on food and agriculture are now a burning question among the mass people and becomes a headache for the government to ensure food freshness security to among the mass people. Hence this turns us to come up with this idea of food freshness and degradation analysis. Primarily we have started our research on Banana fruit degradation analysis to ensure banana's freshness. Comparative research and comparative degradation analysis of banana can be a good solution to ensure food quality and freshness of banana. The aim of this project is to research degradation analysis of Banana.

The type of Banana that is used in this research is called Sagor (AAA genome [a]Musa Sapientum). Two different methods Convolutional Neural Network (CNN) and CONTOUR are used for more comparative study to reflect on degradation analysis. Changes in color shape and black spots of 67 fresh samples of Bananas are observed for seven days. The samples are put at room temperature for seven days. The changes of each of the banana sample are recorded from day 1 to day 7.

For CONTOUR model banana images are captured from two different angles to investigate features for degradation analysis and images are captured using normal resolution smartphone camera and merge them into one image to be used as the test set. On the other hand for CNN model single 134(One hundred and thirty four) one side banana images are taken and after that by using augmentation the datasets are increased into 300 banana images which are used as test set for CNN model. These two comparative approaches provide two magnificent outputs with pleasant accuracy where CNN gives 90% accuracy and CONTOUR provides 60% accuracy. In the future further algorithmic development will be implemented including AI for better approximation.

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CHAPTER 1
Introduction

1.1 Introduction

The manual sorting of defected fruits are time consuming process and sometimes prone to error. Training machines to identify defective or degraded fruits is very essential nowadays. Fresh bananas tend to have mixture of green, yellow color with some brown spots. As the quality of banana is rapidly destructive by the Environmental effect, bananas tend to start degrading from 5th or 6th days if kept in room temperature. The dataset that will be used in this paper are images. The images are taken in daylight and all collected 67 samples of banana are from the same bunch. As our research time was during summer, the average temperature of was around 27 degree Celsius. We have also collected naked eye observation of changes of bananas in shape, color, presence of black spots into excel for more comparative study and research on degradation analysis of banana.

a) **Definition:** Degradation the process in which the beauty or quality of something is destroyed or spoiled [b].

In this proposed method of degradation analysis of banana image processing is used. The day by day changes of banana images are trained through Convolutional Neural Networking (CNN). With the development of CNN model through proper training it becomes more accurate and less time consuming to analyze degradation of banana. CNN model is capable of detecting pixel by pixel changes in the banana samples. It can analyze color changes, shape changes & appearance of black spots on the banana surface and learn the changes taking place during degradation process thus identifies the banana to be fresh or degraded. Appearance of black spots is very important thing in degradation analysis of banana. The status change of banana indicates parameters like black spots, changes in color and changes in shape can also be

analyzed using CONTOUR model. For that our comparative study and research on degradation analysis of banana can be much more efficient & the result could be much accurate. The proposed methodologies and models can be easily developed in our labs to build helpful applications to determine whether the banana is degraded or not and therefore the freshness and nutrition of banana can be ensured.

1.2 Motivation

Freshness of food and food safety is everybody's concern, and it is difficult to find anyone who has not encountered an unpleasant moment of foodborne illness at least once in the past year. Foodborne illnesses may result from the consumption of food contaminated by microbial pathogens, toxic chemicals or radioactive materials.

Degradation analysis of banana will surely pave the way of terminating foodborne illness and will define the days old freshness of banana food so that freshness of banana food using degradation analysis takes a new dimension on determination of food freshness.

There are many systems exist in the field of food freshness detection. The maximum systems are industrial which are controlled by computer and laser vision. There is a very few mobile applications for mass people to detect food freshness. **CTech** Israeli startup Clarifruit (listed as AclarTech) uses computer vision and machine-learning technology to quickly evaluate the quality, ripeness, and freshness of fruits and vegetables.

Clarifruit has developed a produce-monitoring mobile app that scans fruits and vegetables and analyzes their condition to determine whether or not they are ready to go to market. According to the company's website, the Clarifruit app can analyze data on such elements as the color, size, firmness, and sugar content of a fruit or vegetable. The app can also detect imperfections such as stains. The app allows growers to instantly assess produce and transmit the data throughout the supply chain. The goal, the company said in a statement, is to cut down on food waste and provide an alternative to expensive and time-consuming manual testing.

In addition, degradation analysis of Banana by using comparative approaches CNN and CONTOUR we develop a method for detecting bananas days old freshness and to detect the certain degraded areas. It also calculate its percentage of degrade portion of a degraded banana whether banana is in its good, best or worst state. So these comparative methods would be able to add a new dimension in food freshness detection sytem.

1.3 Rationale of the Study

Establishing mobile application and applying our proposed models into the system would be a great work output for our one year comparative research on food freshness detection and degradation analysis of banana. The continuous hard labor patience work with machine learning and python (bokeh and matplot) these two methodologies CNN and CONTOUR Analysis our research object and goal becomes more specific and consistent. Several works have done on quality and safety assurance of food freshness but no study has done to meet the described problem such as foods days' old freshness, its degraded portion areas and its percentage whether it is still eatable or not. Therefore, the problem still exists as to work from the very fundamental. Our study intends to meet these puzzles to explore more goals into near future and to give a structure to a fined solution. Researchers are still going on to solve this problem more precisely and more efficiently.

1.4 Expected Outcome

This research has a long term vision and goal to achieve most efficient way to detect not only freshness of banana but also other foods and to become more specific to meet mass people's crisis on food freshness demand. The developed structure includes many sub objectives. Among the sub objectives it is expected to solve the following ones:

- Ability to detect banana's degraded or spoiled black grey spots.

- Ability to detect days old freshness of banana. Such as the banana is 2 days old or 7 days old.
- Reducing cost of detecting food freshness.
- Ability to detect degraded percentage.
- Finally to detect whether the banana is degraded or not.

CHAPTER 2

Background

2.1 Introduction

As food freshness is a world concern topic there is no scope to escape the harsh reality of food adulteration. From top to bottom of the community food freshness must be ensured and technology is the most efficient way to reach this precise goal. On the other hand the huge technologies in industrial field should be come into the day light so that comparative research can be done and much friendlier environment can be created to reach among the general to make them learn about easy food freshness detection system. Banana degradation analysis is one of a kind to reach bananas freshness goal among the general by developing through friendly mobile applications. Any governance body can ensure food freshness and can be able to detect food freshness by reducing the food adulteration through using development models like ours.

2.2 Related Works

In past and recent days a lot of research has been done before on fruit freshness and fruit quality evaluation but not quite like ours. Our work is specially based on degradation analysis of Banana to verify its natural freshness using machine learning AI methods. Our dataset is purely real life field dataset, so it has its consistency & validity for real life experiment on degradation analysis of banana.

For more information & knowledge we have gone through several great works that has been done like a paper written by Peng Wan, Arash Toudeshki, Hequn Tan, Reza Ehsani [3] presented the methodology for detecting fresh tomato maturity by using computer vision. The system starts the process by combining Green, Orange & Red tomato feature colors value with the help of back propagation neural network (BPNN) classification technique. For taking tomato images into the lab, a maturity detecting computer vision technology was specially designed.

Vahid Mohammadi, Kamran Kheiralipour, Mahdi Ghasemi-Varnamkhasti [4] wrote about the methodology of detecting the maturity of persimmon based on image processing. This methodology showed three major maturity stages which were prepared by image analysis technique, an automatic developed algorithm to classify the foods and also physical, nutritional & mechanical properties were used to compare the image analysis.

Hetal N. Patel, Dr.R.K.Jain, Dr.M.V.Joshi [5] developed fruit detection system by using improved multiple features based algorithm. To detect the fruit and to extract all related features from fruit images, an image processing algorithm was trained for efficient feature. The algorithm was developed with an aim of calculating different weights of extracting features like intensity, color, orientation and edge of the input test image.

A very efficient work from Bindu Tiger and Toran verma [6] , presented the normal and infected apple recognition techniques. By using two-layer Feed-forward network, with the help of sigmoid hidden and output neurons this proposed method classifies and recognizes apple images based on obtained features values. The featured toolbox supports radial basis networks, feed forward networks, self-organizing maps, dynamic networks and other proven network paradigms. This work represents the recognition of generated signals by artificial neural network technique and the supported platform is MATLAB 7.8.0 software.

Brilliant contour based image segmentation by Patrick Etyngier, Florent Segonne, and Renaud Keriven[13] , showed active contour based image segmentation by using Machine Learning Techniques. Here they proposed and introduced a nonlinear shape prior for the deformable model frame work that we learn from a set of shape samples using recent manifold learning techniques.

Assaf Hoogi, Arjun Subramaniam, Rishi Veerapaneni, and Daniel L Rubin [14] introduced about using convolutional neural networks and texture analysis by adaptive estimation of active contour parameters. By supplying a novel method for adaptive estimation of active contour parameters, they presented a generalization of the set segmentation approach. The presented segmentation method is fully automatic

and once the lesion has been detected. The location of the level set contour relative to the lesion is estimated by using a convolutional neural network (CNN). They evaluated the model against state of the art CNN based and active contour techniques.

Agus Pratondo, Chee-Kong Chui, Sim-Heng Ong[15] presented a methodology on region-based active contour models to integrate machine learning model with the help of region-based active contour models in medical image segmentation.

2.3 Research Summery

We have researched the problem and all related works (what could found) to establish a clear understanding of the domain of the problems and to find out what has been done so far. Some of the other works of other authors have been reproduces in the research partially to get a better result. The investigations show that the problem of food adulteration still exists, further investigation and much more efficient development for all of the people in general is needed to be addressed and solved.

2.4 Challenges

Banana degradation analysis consists of two different methodologies CNN and CONTOUR. The sample image datasets is taken by normal resolution smartphone camera. Changes in color shape and black spots of 67 fresh samples of Bananas are observed for 7 days. The samples are put at room temperature for seven days. The changes of each of the banana sample are captured from day 1 to day 7.

The image data sets are taken in normal environment for seven days with seven different temperature and humidity during daylight. So controlled environment is one kind of challenge for taking image datasets.

Another big challenge is noisy images with blurry shadows because of not being in a controlled environment. Because of those shadows, identifying degraded areas in noisy images is a big challenge for CONTOUR model.

Acquiring big image dataset is the most challenge we have faced in our research of degradation analysis of banana. The fresh ripe banana bunch from tree is not available because most of the cases half ripe banana bunch is used to collect. So using half ripe bunch of banana sample to degrade analysis and for identifying day's old freshness of banana is not the best solution. So collecting rich ripe banana bunch from tree is a challenge in our project.

CHAPTER 3

Research Methodology

3.1 Introduction

After investigating all existing approaches, we have learned all the convenience of approaches and their abridgements and all available possibilities as well. This chapter of our study contains every step to our proposed methodology.

3.2 Proposed Model and Dataset

A bunch of fresh banana from garden is experimented through 7 days and day by day its changes are saved for its different stages. The 7 days experimentation is applied on 67 samples of banana. Here are some banana samples in [Figure.1] and their stages from day 1 to day 7 are shown. 67 samples of bananas are stored as image format [Figure: 1] and the status of banana is stored in excel sheet. Displays the changes of banana quality from day 1 to day 7.

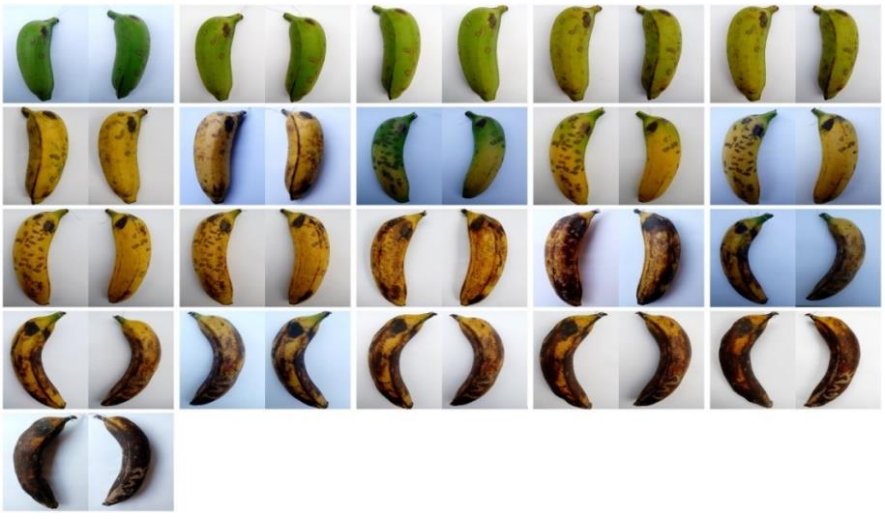


Figure.1: Stages of Green, Half ripe & Ripe Banana samples from Day 1 to Day 7

After observing through green, half ripe & ripe bananas from the same bunch of banana tree we can visualize a degradation state bar chart [Figure.2]

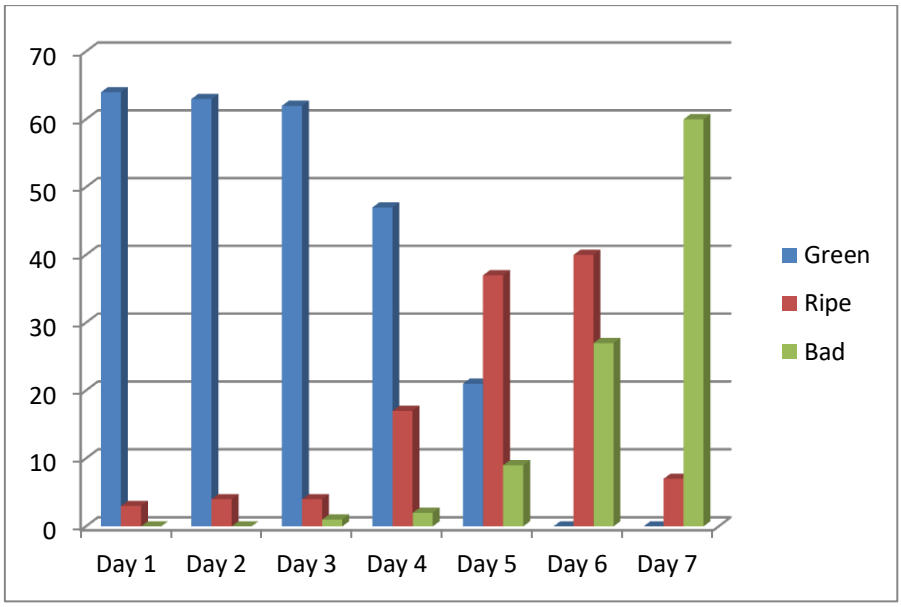


Figure.2: Bananas freshness and degradation evolution from Day 1 to Day 7

Here we can see in day 1, among the 67 samples 64 are green and 3 are ripe with no degradation or bad samples. In day 2, 63 are green and 4 are ripe with no degraded sample. In day 3, 62 samples are still green and 4 are ripe with 1 degraded sample. Day 4, 47 samples are remained green and the rests 17 are ripe with 2 degraded samples. Day 5, 21 samples remain green and 37 are ripe, 9 get degraded. In day 6, there is no green sample 40 of data's got ripeness and 27 get degraded. Final day7, 7 data remains ripe, rest 60 samples get degraded.

The observations are stored as image format. The Datasets are used to train the CNN model. This specially modified automated system is designed to overcome and ignore the problems of manual techniques on banana degradation analysis. Features like color of banana, shape of banana, black spots and ridge of banana are key features to analyze the degradation of banana. The CNN model uses these key features to identify the status of banana.

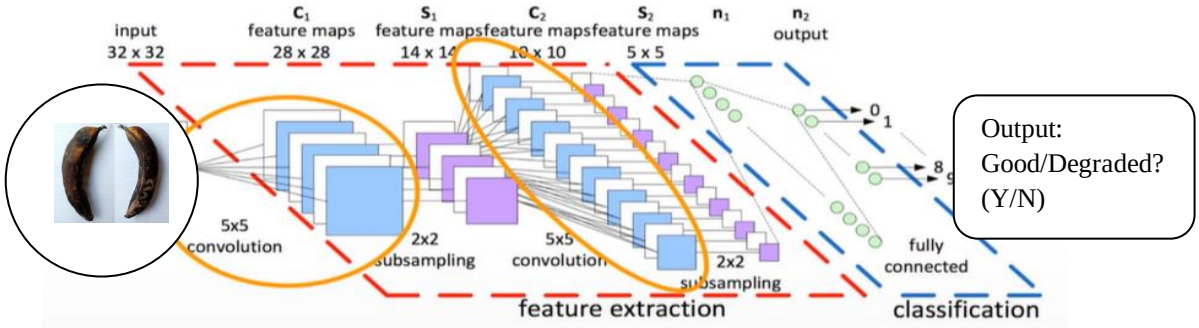


Figure.3: Graphical presentation of CNN Model.

The proposed CNN model classifies the input image as either fresh or degraded. Filter is chosen to be 3 by 3 in size in each convolutional layer to reduce computational cost. Shape of each layer is 150 by 150 pixels. The pooling size is chosen to be 2 by 2. The Model contains three convolutional layers and two dense layers. The first dense layer contains 128 neurons; the Last dense layer of the Model contains a single neuron, as the classification is binary, 0 for Degraded & 1 for fresh.

3.3 Detailed Methodology

This portion contains detailed step by step details of our proposed methodology is shown below:

3.3.1 Proposed CNN Layer:

CNN layer structure and pseudo code is provided below:

Algorithm: 3.3.2

a) 2-dimensional convolutional layer with 32 filters, 3 by 3 kernel size, input shape = (150, 150, 3), and rectified linear unit activation function

b) 2-dimensioanl Max pooling with 2 by 2 sizes

c) 2-dimensional convolutional layer with 64 filters, 3 by 3 kernel size, input shape = (150, 150, 3), and rectified linear unit activation function

d) 2-dimensioanl Max pooling with size = 2 by 2 size

e) 2-dimensional convolutional layer with 64 filters, 3 by 3 kernel size, input shape = (150, 150, 3), and rectified linear unit activation function

f) 2-dimensioanl Max pooling with pool size = 2 by 2

g) Flatten Layer

h) Dense layer with 128 unit and rectified linear unit activation function

i) 50% dropout

j) Dense layer with 1 unit and sigmoid activation function

k) Compiling with binary cross entropy loss, adam optimizer, accuracy metrics

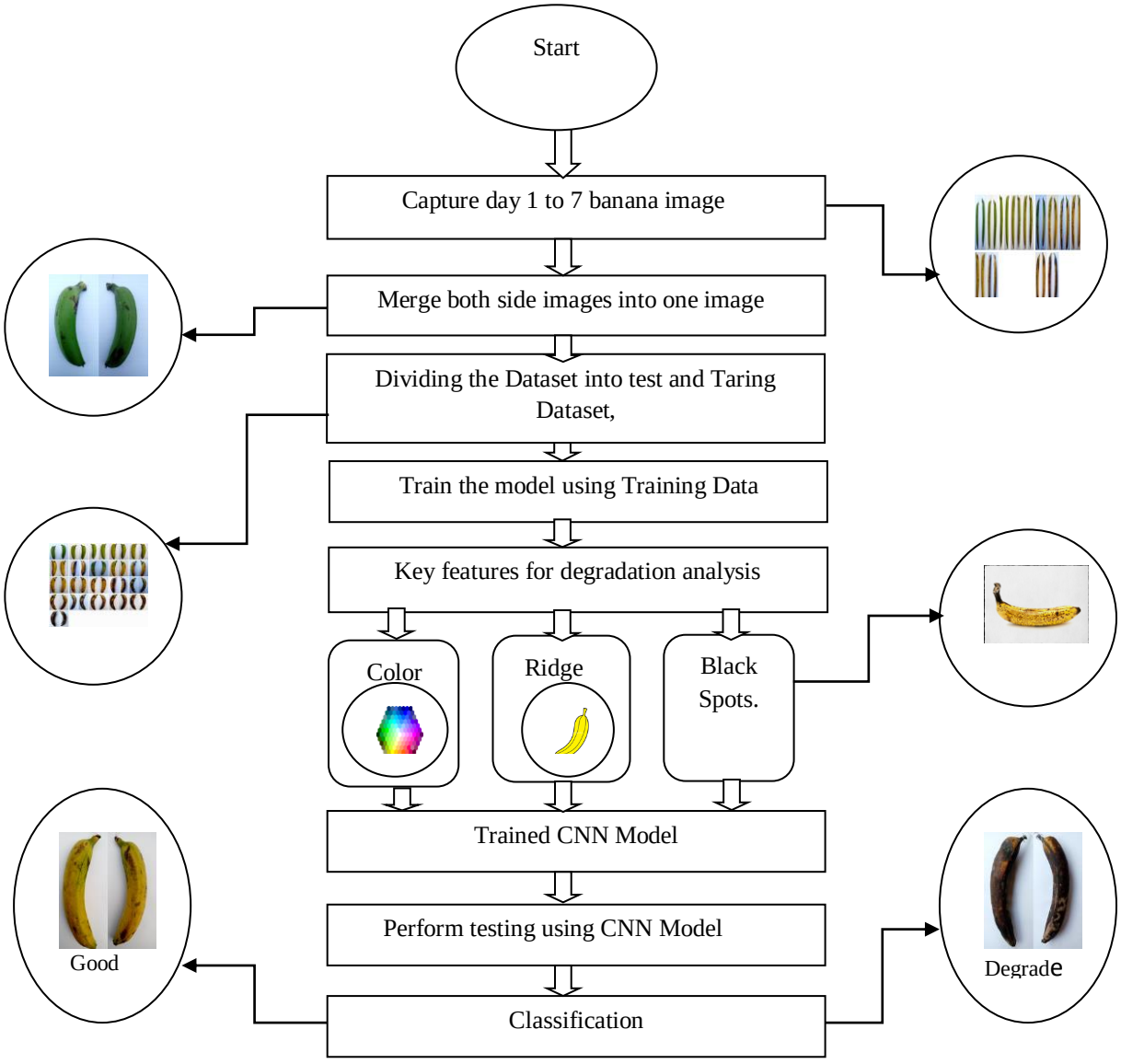


Figure.4: Degradation analysis of Banana by using CNN

3.3.3 Arrange the Dataset

CNN model will classify the data in 2 classes

1. Fresh (day 1 26'C & day 2 25'C)
2. Degraded (day 7 25'C)

20% data from the dataset are used for validation and the rest are used to train the model. Among the seven days image data 1st and 2nd day's data are considered as fresh class. 7th days data are considered as degraded class.

3.3.3.1 Model Summery

Convolutional Neural network model Layers and parameters per layer are represented in the table below

Layer (type)	Output Shape	Param #
conv2d_13 (Conv2D)	(None, 148, 148, 32)	896
max_pooling2d_13 (MaxPooling	(None, 74, 74, 32)	0
conv2d_14 (Conv2D)	(None, 72, 72, 64)	18496
max_pooling2d_14 (MaxPooling	(None, 36, 36, 64)	0
conv2d_15 (Conv2D)	(None, 34, 34, 64)	36928
max_pooling2d_15 (MaxPooling	(None, 17, 17, 64)	0
flatten_5 (Flatten)	(None, 18496)	0
dense_9 (Dense)	(None, 128)	2367616
activation_9 (Activation)	(None, 128)	0
dropout_5 (Dropout)	(None, 128)	0
dense_10 (Dense)	(None, 1)	129
activation_10 (Activation)	(None, 1)	0

Total params: 2,424,065
Trainable params: 2,424,065
Non-trainable params: 0

Figure.5: Model summary Table

3.3.3.2 Learning Curve

Basically, learning curve refers to a plot where x-axis displays time or experience on the other hand the y-axis shows learning or improvement. Learning curves plots are responsible for depicting changes in learning performance over time in terms of experience. The plot can be used to identify the model's performance on the train, validation datasets can be used to identify if the model is well-fit model, underfit or overfit.

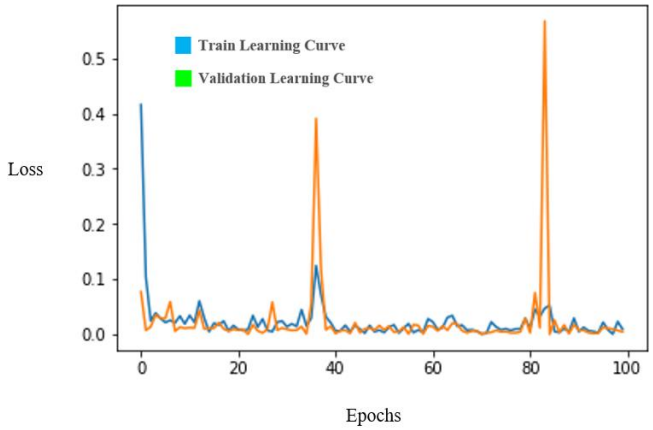


Figure.6: Training and Validation Learning Curve

We can observe decrease in the loss for Training Dataset. The loss for Training dataset is around 0.4160 in the first epoch whereas in the last epoch the loss is around 3.5552e-04. We can observe decrease in the validation loss as well. In the first epoch the loss is around 0.0769 and in the last epoch the lost is 0.0108. From the above graph we can say that the convolutional neural network model is learning from the dataset. The model is trained with 100 epochs, some of the Training loss and Validation loss are presented in the table [Table: 1].

Table.1: Training and Validation loss

Epoch	Time	Training Loss	Validation Loss
1/100	240s, 8s/step	0.4160	0.0769
2/100	236s, 8s/step	0.1020	0.0074
3/100	169s, 6s/step	0.0243	0.0135
4/100	233s, 8s/step	0.0377	0.0350

5/100	276s, 9s/step	0.0290	0.0289
96/100	133s, 4s/step	0.0212	0.0127
97/100	143s, 5s/step	0.0080	0.0108
98/100	135s, 4s/step	3.5552e-04	0.0092

3.3.3.3 Model Evaluation

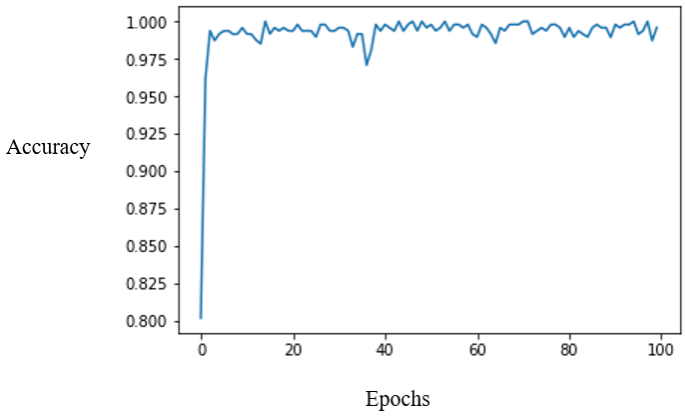


Figure.7: Plot of Accuracy matrices for Training Dataset

The Figure.8 shows the plot of accuracy matrices for training dataset. We can observe that the value of accuracy in the first epoch is around `0.8021`. in the last epoch the accuracy is around `0.9875`. The designed model has been able to classify the data with around 80-98% accuracy. In the first epoch the accuracy rate is near 80%. As the epoch increases the accuracy rate of the model also increases significantly.

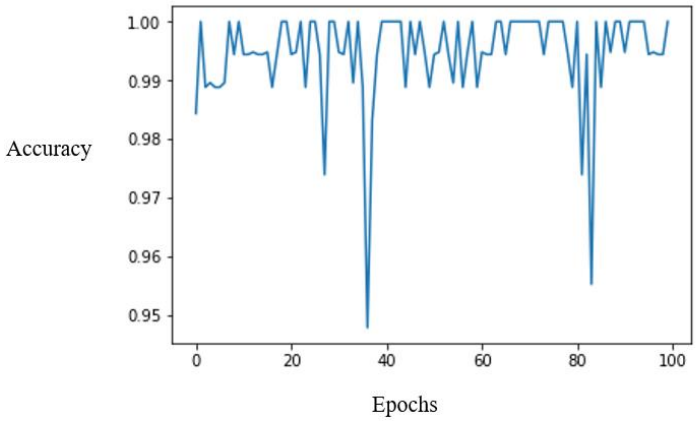


Figure.8: Plot of Accuracy matrices for Test Dataset

The Fig. 10 shows the plot of accuracy matrices for test dataset. We can observe that the value of accuracy fluctuates around 0.9844 to 0.9944. The model is able to classify degraded and fresh banana with almost 98% to 99% accuracy.

Some of the training and validation accuracy values are presented in the table below [Table: 2]

Table.2: Training and Validation accuracy table

Epoch	Time	Training Accuracy	Validation Accuracy
1/100	240s, 8s/step	0.8021	0.9844
3/100	169s, 6s/step	0.9937	0.9888
4/100	233s, 8s/step	0.9937	0.9896
5/100	276s, 9s/step	0.9917	0.9888
6/100	243s, 8s/step	0.9937	0.9888
97/100	143s, 5s/step	0.9937	0.9948
98/100	135s, 4s/step	1.0000	0.9944
99/100	157s, 5s/step	0.9875	0.9944

3.3.4 CONTOUR

In contour analysis of an object image, it conquers the boundaries of an object and detect defect, degrade areas. [15] Contour analysis are very much effective on image segmentation with the help of some defined boundaries but in terms of morphological analysis and inhomogeneity it becomes more complicated and often fails when it is applied to images containing intensity and inhomogeneity. The Contour model is evaluated and segmented in several times to compare with typical different kinds of active contour models. Therefore we can easily able to segment banana test images with different trained images of different intensity and characteristics. The contour model pseudo code is finally demonstrated here:

Algorithm: 3.3.4.1

a) Read image from director b) Convert Image= BGR_2_HSV c) Convert color format from BGR to HSV d) Filter result (upper_lower) e) Draw contour f) Stack result (Banana)

g) Resize Banana (Max_dimension)

h) Print image

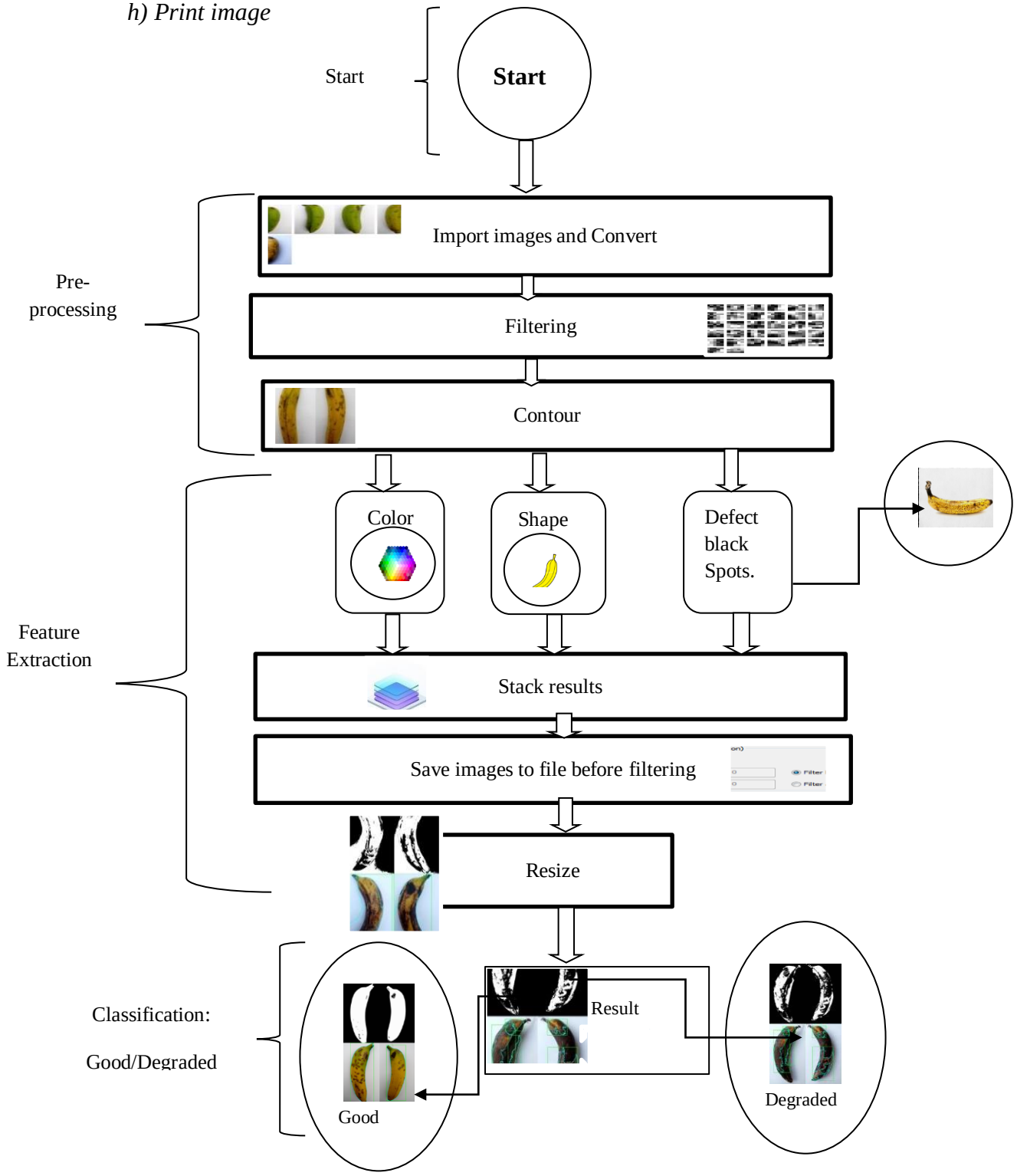


Fig. 9: Architecture of the proposed Contour Analysis

On the other hand, these traditional analyses of an image often utilize pixel intensity which is mostly very sensitive on parameter tuning. Machine learning algorithms are therefore very much effective on handling inhomogeneity but for more comparative approach on degradation analysis of banana we dived into this contour analysis.

The proposed contour analysis is six steps of working procedure along with filtering, contour shapes, stack results, save before filtering & resize. This system is composed of three main stages; namely ***Pre-processing, Feature Extraction and Classification*** stages [Figure.9]. The proposed contour approach is applied with two algorithms for feature extraction and classification. Contour analysis is evaluated and segmented in several times to compare with typical different kinds of active contour models. Therefore we can easily able to segment banana test images with different trained images of different intensity and characteristics. The datasets we have used is merged banana images captured from both angle using HTC smart phone. Captured image datasets contain colored JPG images resolution of 8 M pixels.

3.3.4.2: PRE-PROCESSING

During pre-processing stage, all useful libraries are imported and load images to make them convert. After that, we convert the frame from BGR to HSV format so that later we can create a mask. We have defined HSV ranges with lower and upper of a specific color. In this contour analysis to detect degrade areas we chose gray. After that to find the contours we have used the opencv built in function findContours.

3.3.4.3: FEATURE EXTRUCTION

As we previously mentioned that surface color is the main characteristics for degradation analysis, to detect degrade portions and black spots we chose gray. This system uses HSV colored histogram and color moments for degrading images classification. So, in this case of feature extraction we use PCA algorithm. PCA (Principal Common Analysis) algorithm is a statistical technique that widely used in image features extraction to ensure better image recognition and classification. After that the extracted features is stacked, save all the images before filtering and resize them.

3.3.4.4: CLASSIFICATION

The used features for classification are combination of colored HSV histogram and color moments. Moreover morphological ellipse is employed with different kernel

function. In some cases there is in need of elliptical/circular shaped kernels. Specially to classify good or degraded images of an object and to identify different shapes likes round or curvy [Fig.10].

Figure.10: Defected and damage areas in contouring analysis

In some cases there is in need of elliptical/circular shaped kernels. Specially to detect black matters or degraded spots in an object to identify different shapes likes round or curvy, OpenCV has a function, cv.getStructuringElement().

3.3.4.5 MORPHE_ELLIPSE

We have applied another helpful structuring element from active contour model cv2.getStructuringElement(cv2.MORPH_ELLIPSE,(9,9)) to calculate morphological gradients [Fig.14].

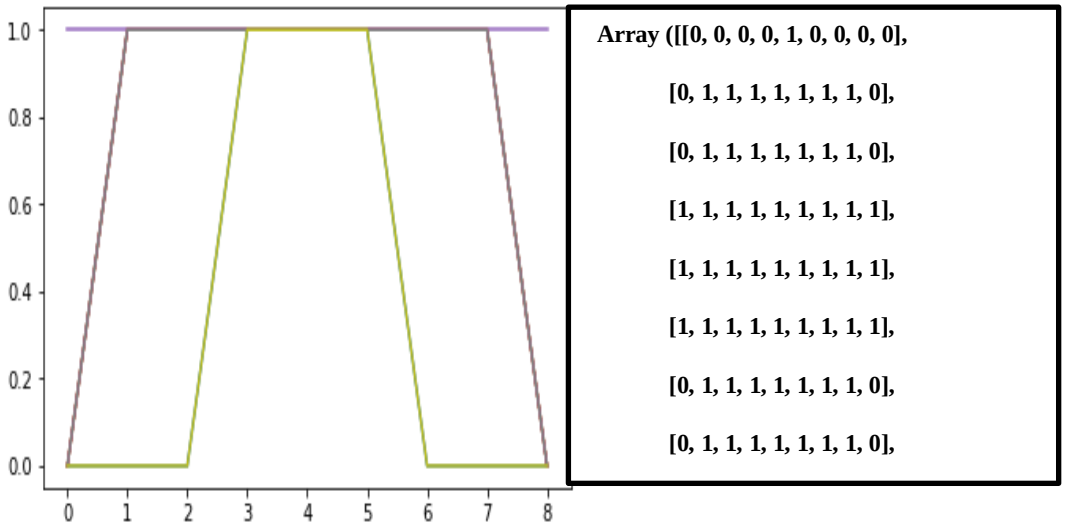


Figure.11: Plot Kernel & array

For classification of degrade stages we have applied RF (Random Forests) algorithm. The inputs are number of epochs, training dataset, feature vectors and rest is their corresponding class. Outputs are the degrade stage of each image in the training dataset.

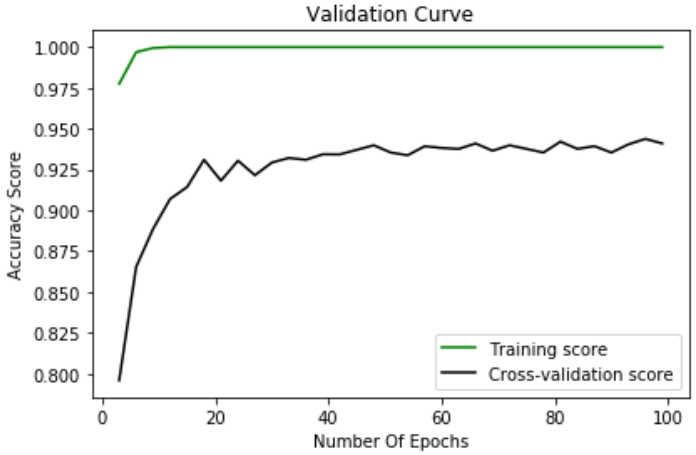


Fig.12: Contour Validation curve using RF classifier

RF is trained using linear and polynomial order with 3 kernel functions (result, lower, and upper) and cross -validation. The result is gained with a pleasant 98.75% accuracy [Figure.12].

At the very end after all this calculation & structuring elements we applied python (bokeh and matplot) to calculate the percentage of marked degrade parts in each image datasets. Finally we recorded all the average percentage of degradation analysis into excel sheets according to days from day 1 to day 7 & therefore we visualize a degrade evaluation [Figure.13].

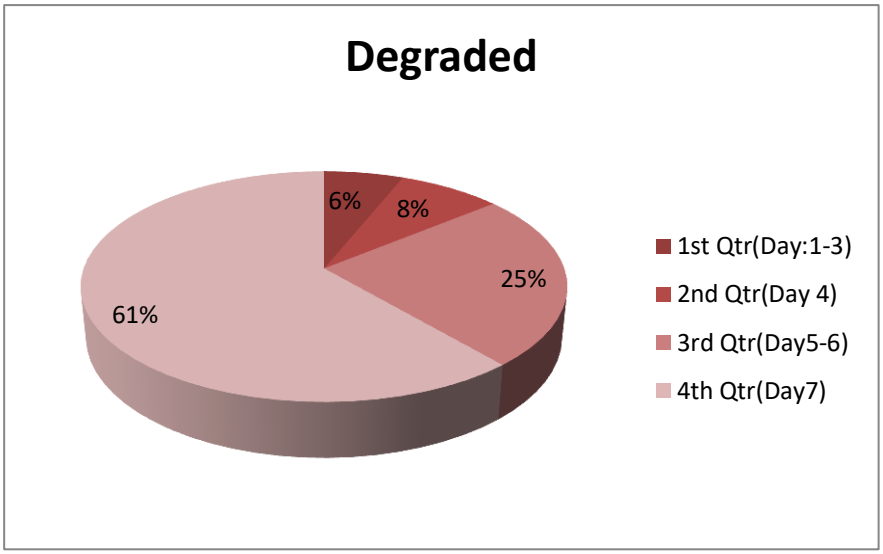


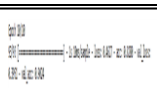
Figure.13: Degrade evaluation of Banana after contouring analysis.

We can see in our 7 days data collection, from day1 to day3 with an average temperature of 25° Celsius degradation of 67 banana sample is 6%, in day 4 degradation is 8% with 29° Celsius, between day 5 to 6 it's 25% when average temperature is 27° Celsius & in day7 degraded sample is 61% with presence of 28° Celsius temperature. So gradually by the passage of time all the banana samples are losing their visual pleasant look & getting old. So all the degraded samples will be considered as bad sample which are completely wasted & not eatable.

3.3.4.6 Experimented Results

After training all the test & train sets of 67 samples using CNN & CONTOUR methodology the degradation analysis of Banana comes to an end. Here is the final predicted result in [Table.3].

Table.3: Final result of degradation using CNN & CONTOUR

METHODS	NO. OF BANANA SAMPLES	ACTIONS		RESULT
		INPUT	OUTPUT	
1) CNN	300			Degraded / Good 98% Accuracy
2) CONTOUR ANALYSIS	134			Degraded / Good 98.75% Accuracy

These proposed techniques include CNN and Contour Analysis where Principal Component Analysis (PCA) and Random Forests (RF) algorithm is applied for quality detection of banana fruit. Training dataset is divided into two classes which is representing the different stage of banana. The classes for degradation analysis of banana are degraded and good. In this article a comparative study between CNN and Contour Analysis with two (PCA & RF) algorithm for the degradation analysis stages of banana has been presented. We have a motto to make it more consistent, reliable and accurate.

Later we will also improve our models which will be able to determine freshness class & determination of freshness of other fruits. The obtained results and accuracy for CNN and Contour Analysis are respectively 99% and 98.75% which are very good for the seven days test and training sets on 67 chosen banana fruits images of different color, shape and size. This featured models and system can be easily employed on degradation analysis of banana fruit. In near future the quality and degradation detection of banana fruits based on CNN, CONTOUR should be compared with other mechanical and automated techniques as well.

CHAPTER 4

Discussion, Conclusion and Future work

4.1 Discussion

We present techniques using Machine Learning and Contour model for quality detection of fruit (Banana). We have a motto to make it more consistent, reliable and accurate, later we will also improve our models which will be able to determine freshness class & determination of freshness of other fruits. The obtained results and accuracy for CNN and Contour model are respectively 98 to 99% and 98.75% which are very good for the seven days test and training sets on 67 chosen banana fruits of different color, shape and size. This featured models and system can be easily employed on degradation analysis of banana fruit. In near future the quality and degradation detection of banana fruits based on CNN, CONTOUR should be compared with other mechanical and automated techniques as well.

4.2 Conclusion

Agriculture and horticulture is undoubtedly the largest economic sectors and it plays the vital role in economic growth development of developing countries like Bangladesh. Still in many areas, the traditional freshness and degradation inspection of fruits is performed by naked eye observation with the help of human experts. we proposed different models in this paper that are able to detect degraded banana. The whole process from the data collection to test, train it was a long journey. As Banana is very small-time living food and it is easily destructive by natural heat, insect's effect besides we have done our research between hot summer seasons with an average temperature of 27° Celsius, So, we observed all the banana samples for 7 days. On the other hand, banana's freshness lasts longer in the winter season which is around 10//11 days. So, it has to be noted in case of any research on fruits like banana. Our collected data & final results in Table.3 are purely based on 7 days data & in that

case 1 week is enough for banana to get degraded. Due to monsoon weather country humidity and temperature also plays a vital rule on changing banana texture.

4.3 Future Work

This research work can be extended in many extents to make it more market suitable and friendly for all stages of people to become familiar with this development. Our future goal is to implement days old freshness detection and to develop the medium work not only for banana but also for all sorts of foods to make the system more reliable and applicable. Days old freshness detection and applying the development into mobile applications.

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