

Real-time Mango Maturity Detection system using Image Processing

Submitted in partial fulfilment of the requirements for the award of
Bachelor of Engineering degree in Electronics and Communication Engineering

By

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and

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ENGINEERING SCHOOL OF ELECTRONICS AND ELECTRICAL
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Accredited with Grade "A" by NAAC
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DEPARTMENT OF ELECTRONICS AND COMMUNICATION

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of R VINEET RAO (37130438) and K R VENKATA PRASAD (37130433), who carried out the project entitled "Real-time Mango Maturity Detection system using Image Processing" under my supervision from December 2020 to April 2021.

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DECLARATION

We, R VINEET RAO (37130438), K R VENKATA PRASAD (37130433) hereby declare that the Project Report entitled “**Real-time Mango Maturity Detection system using Image Processing**” done by us under the guidance of Dr. M.S. GODWIN PREMI, M.E., Ph.D. and at Sathyabama Institute of Science and Technology is submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering degree in Electronics and Communication Engineering.

DATE:

PLACE:

SIGNATURE OF THE CANDIDATES

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ABSTRACT

In food business and agricultural business, the right grading of fruits is extremely necessary to extend the profit. In this proposed system, a method for automatic grading of mango in step with maturity level and quality of the mango and physical features has been planned. The planned work is on an intelligent machine vision-based technique for grading of mangoes in three completely different classes, that are decided on the basis of distance where the market is located and market price of the mango. In this system video image is captured by a CCD camera which is placed on the top of a conveyer belt which carries the mangoes, thereafter several image processing techniques are enforced to collect features that are sensitive to the quality and maturity. For the prediction of estimating the quality of mango the Multi Attribute Decision Making systems have been applied. Finally fuzzy logic incremental learning algorithm is being used for grading the mangoes based on maturity and quality. For prediction of maturity Support Vector Regression has been used. The performance achieved by this planned fuzzy inference system for grading of mango fruit is ninety percent approximately. Moreover, the repeatability of the planned system is found to be 100 percent correct.

CHAPTER 1

INTRODUCTION

In India the most awaited seasonal fruit is Mango, for its taste, flavour and enriched quality. Mango trees square measure harvested in several favourable location across the country. Throughout the summer mango square measure are harvested and distributed to numerous markets as per the demand of the market, quality and maturity of the mangoes. The important step is categorising of mangoes, but it is difficult task and troublesome for graders to keep constant track of mangoes. If this process may be achieved mechanically by machine vision the end result will be astonishing and it will save labour and improve the output. The most vital visible attribute of classifying the mangoes is its color, and it is a significant think about purchase by consumer. The color identification is complicated for humans as a result of sensation of eye sight, so square measure is necessary. As color is the sign of matureness for a mango, an inexperienced gradient of yellow won't assess the stage that a mango ought to be consumed. The color sensing element will observe the RGB color intensity of skin of the mango to decide the matureness.

In past, abundant analysis the carried work for fruit grading by machine control through Aroma Analysing Victimization Electronic nose, so as to predict the fruits maturity. In a different work, a Spectrographic Analysis Primarily using micro optic device is conferred for observing the quality and testing the safety of food . Within the analysis the micro-optic sensing element is used to completely discriminate different levels of aging of the mango. Recently maturity prediction for estimating the firmness of the fruits flesh.

The prediction of aging of fruit chiefly involve the non vision based system. There are certain limitations in mass scale grading of fruits at intervals restricted time frame. The strategies ,have several options that are extracted and henceforth principal-component-analysis (PCA) has been utilized, at last for grading purpose classifiers are used. In recent years the significance for use of machine vision in agricultural sector as multiplied . Several applications requiring visual examination online vision based mensuration systems are developed.

CHAPTER 2

LITERATURE SURVEY

[1] M. Stefania , D. Marco, M. Rossano, C. Giovanni, and R. Damiano, “A Spectroscopy-Based Approach for Automated Non-destructive Maturity Grading of Peach Fruits”, IEEE Sensors Journal, vol.15, no.10, pp.5455-5464, Oct. 2015.

This paper presents an automatic approach for peach fruit maturity grading that, by exploiting fibre-optic spectroscopy-based sensors and variable process techniques, minimizes the operator intervention whereas reducing discharge and waste. The employment of a spectroscopical sensing element complies with the supposed non-destructive activity methodology, that permits quick perennial measurements to be performed at the only fruit level whereas avoiding fruit injury and loss. Maturity grading is accomplished by retrieving estimates of the fruit flesh firmness by means that of variable retrieval techniques that are to be applied to the reflection factor spectra noninheritable with the prism spectroscope and by process the retrieved values among the framework of a maturity fuzzy classifier. Maturity grading is accomplished by retrieving estimates of the fruit flesh firmness by means that of variable retrieval techniques which are applied to the reflection factor spectra noninheritable with the prism spectroscope and by process the retrieved values among the framework of a maturity fuzzy classifier. call|a choice|a call web is developed to produce the user with maturity class decision and associated reliableness. Experimental results show that the approach is effective for machine-driven maturity grading of peach fruits laid low with a high degree of variability. This paper lays the foundations for the conclusion of easy-to-use property machine-driven maturity grading systems.

[2] C. McCarthy, “Practical Application of Machine Vision in Australian Agricultural Research at NCEA”, IEEE RAS TC on Agricultural Robotics and Automation Webinar, March 28, 2014, Brisbane, Australia.

In the early nineties, the analysis team at the National Centre for Engineering in Agriculture established a name for vision-based machine-driven steering of agricultural vehicles.[4] This work contains a new lease of life with recent funding. A succession of more vision comes are somewhat uncommon, starting from the visual identification of animal species for the culling of savage pigs to vision-based count of macadamia tree haywire. A unifying feature is that the straightforward handiness of low-priced cameras and a framework for group action analysis code victimization DirectX ‘filters’. Machine vision has modified from its earlier standing as a complicated and big-ticket technology to a low-priced answer for additional general instrumentation.

[3] C. S. Nandi, B. Tudu, and C. Koley, “A Machine Vision Based Maturity Prediction System for Sorting of Harvested Mangoes”, IEEE Trans. Inst. and Meas., Vol. 63, No 7, July 2014, pp.1722-1731.

Seasonal fruits, like mango (*Mangifera Indica* L.), area unit harvested from gardens or farms in batches; the mangoes gift in every batch don't seem to be uniformly matured, therefore, sorting of mangoes into totally different completely teams is important for transporting them into different locations. With this background, this paper proposes a machine vision-based system for classification of mangoes by predicting maturity level, and aimed to interchange manual sorting system. The prediction of maturity level has been performed from the video signal collected by the Charge Coupled Device (CCD) camera placed on the highest of the conveyor belt carrying mangoes. Extracted image frames from the video signal are corrected and processed to extract varied options, that were found to be additional relevant for the prediction of maturity level. algorithmic feature elimination technique together with support vector machine (SVM)-based classifier has been used to spot the foremost relevant options among the at first chosen twenty-seven options. Finally, the optimum set of reduced variety of options are obtained

and used for classification of the mangoes into four completely different categories in step with the maturity level. For classification, associate degree ensemble of seven binary SVM classifiers has been combined in error correcting output code, and also the minimum playing distance-based rule has been applied in deciding part. For the experimental study, the mangoes of 5 completely different varieties were collected from 3 different locations and in 3 different batches. The obtained experimental result found to supply a mean classification accuracy up to ninety-six.

[4] L. Wang, X. Tian, A. Li, and H. Li,” Machine Vision Applications in Agricultural Food Logistics”, IEEE Sixth Int. Conf. on Business Intelligence and Financial Engg. (BIFE), 14-16 Nov. 2013 pp.125 – 129.

Agricultural food's supply must be economical and to produce assurance on the protection and quality of its merchandise that customers might trust. This paper styles a machine vision system by that fruits or vegetables may be detected for defects and damages throughout transportation and storage. the colour bar chart extracted in native image patch is employed as image feature and therefore the Linear SVM (Support vector machine) is employed for model learning, that provides sensible hardiness, higher accuracy and modest calculation prices. in an exceedingly case of apple scrutiny, our system realizes a recall rate of ninety-six. Eight percent and a false detection rate of Sixteen percent. By the output of this scrutiny, agri-food producers are ready to stop the merchandise with deformity and blemishes from reaching the tip customers, thereby the protection and quality of the agri-food markets may be bonded.

[5] Q. Li and S Ren “A real-time visual inspection system for discrete surface defects of rail heads”, IEEE Trans. Instrum. Meas., vol.61, no. 8, Aug. 2012, pp. 2189-2199.

Discrete surface defects impact the riding quality and safety of a line. However, it's a challenge to examine such defects in an exceedingly vision system thanks to illumination difference and also the variation of reflection property of rail surfaces. This paper puts

forward a time period visual scrutiny system (VIS) for distinct surface defects. VIS 1st acquires a rail image by the image acquisition system, and then, it cuts the subimage of rail track by the track extraction rule. after, VIS enhances the distinction of the rail image victimisation the native standardisation (LN) methodology, that is nonlinear and illumination freelance. At last, VIS detects defects victimisation the defect localization supported projection profile (DLBP), that is powerful to noise and extremely quick. Our experimental results demonstrate that VIS detects the Type-II defects with a recall of ninety three.10% and Type-I defects with a recall of eighty.41%, and also the projected LN methodology and DLBP rule area unit higher than the connected well-established approaches. what is more, VIS is incredibly quick with a linear procedure time quality, and it may be in real time to run on a 216-km/h check train below our experimental setup.

[6] H. Zheng and H. Lu, "A least-squares support vector machine (LSSVM) based on fractal analysis and CIELab parameters for the detection of browning degree on mango (Mangifera indica L.)," J. Comp. and Electr. Agri., vol.83, 2012, pp.47-51.

This paper introduces a least-squares support vector machine (LS-SVM) classifier to find the degree of browning on mango fruits as a perform of form dimension (FD) and $L=a*b$ values. Our results showed that the most effective classification accuracy of browning degree was up to 100% victimization the LS-SVM classifier supported FD and $L=a*b$ ($\gamma = vi.13$, $\sigma^2 = 9.36$). However, the proper classification rates of eightyfive.19% and 88.89% were achieved for the LS-SVM models supported FD ($\gamma = one.13$, $\sigma^2 = 5.52$) and supported $L=a*b$ ($\gamma = vi.68$, $\sigma^2 = 2.44$), severally. Therefore, this study indicated the chance of developing a probably helpful classification tool victimization the LS-SVM combined with FD and $L=a*b$ values for classifying the degree of browning on mango fruits throughout process, storage and distribution.

CHAPTER 3

EXISTING SYSTEM

The application for grading of fruits and vegetables in the agricultural sector has been introduced in the previous existing system. In order to evaluate the quality of various kinds of fruits an automatic method for mapping of colours has been implemented. The three-dimensional Red Green Blue colour grading is converted to binary image with the help of polynomial function of order two this is done so as to make the maturity into simple grey scale image function in the domain which it is being transformed. The polynomial co-efficient are obtained by using the squared method of least errors. Fifteen test samples of an agricultural product is selected and the accuracy obtained was approximately ninety-four percent was the obtained accuracy.

Many other fruit classification applications are still under development having the same kind of machine vision system. Few examples are detecting maturity level of peach by comparing it to ground colour, detection of apples and strawberries from orchids that is estimated using their quality of ripeness. Categorising fruits by RGB analysis and classifying into three stages to obtain ninety percent accuracy.

DISADVANTAGE

- The main drawback of this method is that it does not take all attributes of a fruit for its classification.
- It does not even work for different breeds of same fruit as it is only trained for same kinds of fruits.

CHAPTER 4

PROPOSED WORK

In the projected work we've got established an automatic machine vision-based system for classification of cultivated mango according to their quality. This work is an extended improvement over previous work on mangoes in two views. initial one is that the development of appropriate rule for estimation of mango quality on the premise of size, form and surface defects. The second improvement is to mix algorithms, for creating the projected system additional economical for the vendors to reason mangoes per given inputs of market distance and desirable quality of the mangoes as in demand by the market. On the opposite hand, some markets able to pay a lot of higher worth for higher quality mangoes. Therefore, mangoes are to be classified judiciously, by sensing appropriate hand-picked parameters.

Background is eliminated and contour detection exploitation Graph Contour trailing methodology. within the projected system pictures are captured exploitation 10 mega pixel camera. it's quite obvious, higher resolution camera will give higher performance at the price of computation. The resolution of extracted still frame at the speed of thirty frames per second was 640X480. Since common standards of resolution is 640X480 and cameras with this resolution are cheaper so in gift system, it's been thought-about.

ADVANTAGE

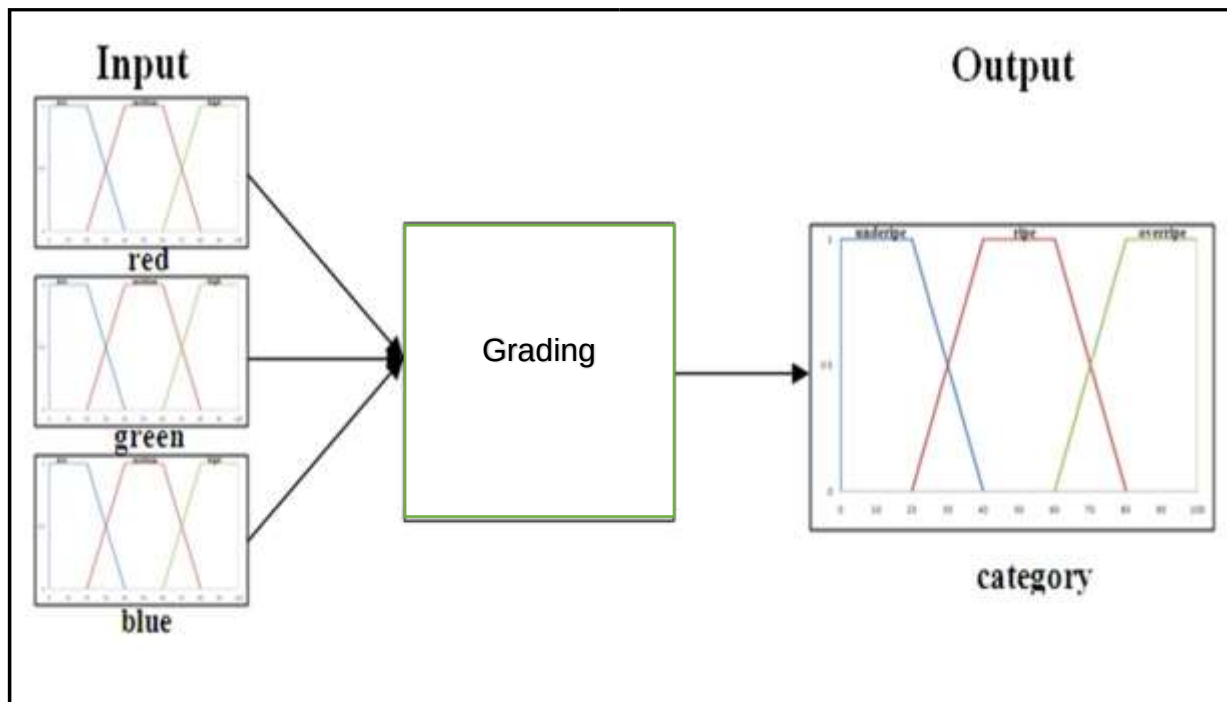
- This machine vision-based system for grading of harvested mangoes supported quality level.
- Mangoes are to be classified judiciously, by sensing appropriate hand-picked parameters.
- Prediction accuracy is high.

The machine-driven mango fruit grading method during this projected work is split into two teams, one is estimation of maturity and other is determination of quality. within the projected work two-layer classification i.e., initial layer is SVR and MADM and also the second layer fuzzy progressive learning technique is employed. within the initial layer prediction of maturity level exploitation SVR and analysis of quality exploitation MADM is completed one by one, because the vendors will enter these two inputs within the projected system, depending on the distance from market and market price. Within the second stage fuzzy progressive learning rule has been applied to classify the mango into three completely different grades, conjointly the vendors will select any combination of grade.

Grade	Attributes for gradation
G1 (Good)	Mangoes in this category should be matured and sensible quality. they need to be characteristic of the variability. they need medium size and weight, slight or no defects in form and skin.
G2 (Medium)	This category includes mangoes that are semi-mature and satisfy the minimum quality needs. the subsequent defects, however, could also be allowed, provided the mangoes retain their essential characteristics as regards the quality: defects in form and skin. they need lightweight weight and tiny size.
G3 (Poor)	Premature or over mature mangoes having massive skin defects and form defects, with little size and weight are during this category. Generally, such mangoes aren't equipped to the buyer, however could also be used for industrial process

Different grades of mangoes

For this, Support Vector Regression (SVR) used to work out the amount of actual days that the harvested mangoes is sent and MADM system has been employed for estimation of mango quality from the standard attributes like form, size and surface defects. Finally fuzzy progressive learning rule has been applied to mix the choices of SVR and MADM on maturity and quality severally, for final gradation of mangoes into the four completely different classes.



The fuzzy inference system consists of three inputs and one output

1) MATURITY DETECTION

Before experimental works, each mango was presented to five independent experts for recording expert's opinion. The average nearest integer of the five expert's opinion was considered as expert predicted days-to-rot. Only those mangoes were collected which having days-to-rot in the range of 5 to 14 days, and for each case (i.e. days-to-rot) total 10 number of mangoes were collected, having accumulated total of 100. The same procedure was followed to collect another 100 number of mangoes in 2nd phase. After collection, mangoes were tagged by some serial number and images of the mangoes were collected by a CCD camera starting from day-0. Then the mangoes were placed in the package in the same manner as used for the transport of the mangoes to different cities. On the next day each mango was taken out from the package carefully for taking image for the day-1 and also presented to the five experts and their predicted days-to-rot were recorded, the same process was followed for all the days.



4.2- Sample images of different grades of mango,

(a) G1-good, (b) G2- medium, (c) G3- poor

The mangoes which started rotten after some days were removed from the package and no further processing was done of these mangoes. In this manner total 2184 number of images of mango were collected. One interesting observation was that

the expert predicted days were not also correct, some mango start rotten before the days-to-rot and some after. In the work a mango was considered rotten if two percent of the skin surface gets dark color (as per the convention of the company). The corresponding days were considered as actual-days-to-rot.

For the training of the SVR model and testing of SVR model, all the twenty-seven features are extracted, details have been discussed in previous study from the images of mango that were arranged in a matrix, where each row represent a vector's feature which is having dimension. Total number of rows is 2184, The vector's feature in the matrix are being arranged ascending order format of actual-days-to-rot. That is initial rows constitute the feature vectors of those mangoes, which had only one days left to get over matured. Similarly next set of rows for those mangoes having 2 days left, and it was up to 16 days, though collected mangoes was up to 14 days as predicted by experts, but actually some mangoes sustained up to 16 days. Then actual-days-to-rot was considered as a target value for each of the feature vector. This process helped to increase the data set size, for training and testing.

Then from this feature matrix training and testing data set was created, by drawing fifty percent of the feature vectors for training and remaining fifty percent for testing the performance of the SVR model. The drawing process for training data set was random from each class, where a class contains all the feature vectors of those mango images having same number of days left for actual-days-to-rot. Half of the feature vectors were kept for training and remaining half for testing. This process was followed for all the classes.

After forming the training and testing data set next task was to form the SVR model. There are three parameters for controlling the regression model, the loss function, the kernel and additional capacity control C . In the current work these parameters were experimentally obtained, by training the SVR model with training data set and evaluating the performance of the SVR model with the help of testing data set.

2) FEATURE EXTRACTION FOR QUALITY ATTRIBUTES

A. SIZE ESTIMATION

This is one of the most important quality for classifying of mango, the large size of the mango is considered of better quality. The size is estimated by calculating the length of longitudinal axis and transverse axis, from the image provided. To compute these lengths first mango image is rotated in such a way that the apex will be at the top then the image is binaries to separate the fruit image from its background as shown in Fig.4(b). The maximum major axis (L_{max}) is detected in the vertical direction and maximum minor axis (W_{max}) is detected in the horizontal direction as shown in Fig.6(b). Then the total number of the pixels (N_p) on these two axis is found. The actual lengths are measured by vernire scale and the rate between the pixel and the actual length is called A, and is calculated by:

$$A = \frac{\text{the pixels}}{\text{actual length}} (\text{pixel/mm})$$

Through a lot of trials and calculations, for 10MP camera keeping distance from camera to the object is 20cm, the value of A is gotten 14.1 (pixels/mm). The length of this two axis is calculated by the following equation.

$$(L_{max} + W_{max}) = N_p / A = N_p / 14.1$$

B. DETERMINING THE SURFACE DEFECTS

Surface defects is another quality attribute used by the farmer or customer. Experimentally it is seen that the blue value is very high in defect pixels compare to healthy pixels. The difference of average R, B (i.e. R-B) value and G, B (i.e. G-B) value of vertical slice through the longitudinal axis from apex to stalk is shown in Fig. 5. The vertical slice from apex to stalk of “AM” variety mango is shown at the top of the graph. It is clearly noticed from the graph that the average RB value and G-B value of the vertical slice, both are very less (less than 80) for defect pixels and very high (80 to near about 190) in healthy pixels. So, using simple thresholding method the defect pixels is identified. Experimentally it is also noticed that this threshold value is different for different varieties of mango. Then the number of defect pixels are calculated where from the percentage of defect area is determined.

C. MEASUREMENT OF SHAPE

In the planned system mangoes area unit thought of adequately by two-dimensional views and also the shapes of mangoes area unit retrieved victimization Fourier Descriptors. Presently, there are a unit several strategies out there for associate degreasing form of an object, starting from a straightforward multiple purpose options methodology to a sophisticated geometric options approach. Authors offer elaborated mathematical clarification of Fourier Descriptors (FD) for visual perception, matching and registration. Authors investigated the utilization of Fourier descriptors in identifying star fruits victimization pc vision. One distinctive feature of this methodology is that it uses international image descriptors rather than the native ones, creating it a lot of applicable to real-world pictures. Before this methodology may be enforced, many image pre-processing steps were performed on the mango image.

The image is first of all binarized and second, processed via a sequence of morphological image process. Finally, the article center of mass is extracted victimization

first-order geometric moments and derived victimization Green's theorem as shown. Mathematically, the two-dimensional center of mass (x_c , y_c) is calculated as follows::

$$x_c = \frac{\sum_{k=0}^N y_k (x_k^2 - x_{k-1}^2) - x_k^2 (y_k - y_{k-1})}{2 \sum_{k=0}^N y_k (x_k - x_{k-1}) - x_k (y_k - y_{k-1})} \quad (1)$$

and

$$y_c = \frac{\sum_{k=0}^N y_k^2 (x_k - x_{k-1}) - x_k (y_k^2 - y_{k-1}^2)}{2 \sum_{k=0}^N y_k (x_k - x_{k-1}) - x_k (y_k - y_{k-1})} \quad (2)$$

where, N is that the total variety of boundary element outlined in an exceedingly right-handed direction from any beginning point; is the coordinate of the boundary element, k, the space of every boundary purpose to the centre of mass is calculated as follows:

$$R(k) = \sqrt{(x_k - x_c)^2 + (y_k - y_c)^2} \quad (3)$$

The $R(k)$ is then subjected to separate Fourier remodel (DFT), yielding a one-dimensional feature vector of the mango image. In Fourier house, such transformation is mathematically enforced as follows:

$$|F(m)| = \frac{1}{N} \sqrt{\left[\sum_{k=0}^N R(k) \cos\left(\frac{2\pi mk}{N}\right) \right]^2 + \left[\sum_{k=0}^N R(k) \sin\left(\frac{2\pi mk}{N}\right) \right]^2} \quad (4)$$

Since the descriptors area unit influenced by the form of the contour and by the initial purpose of the contour, therefore, scheming and examining every harmonic element in $F(m)$ offer a sign of the form of mango. For a given form, the plot of Fourier descriptors produces a pattern or fingerprint that unambiguously describe this form.

Theoretically, the order of Fourier descriptors ranges from zero to time. However, one favourable property common to Fourier descriptors is that the high-quality boundary form illustration may be obtained victimization solely a couple of lower-order coefficients. Therefore, solely the primary few elements of $F(m)$ area unit distinct and customarily needed to differentiate the distinction between mango shapes. during this work a form coaching set and form take a look at set is made for every type of each tracheophyte to discriminate smart mango form from ill-shapen ones. However, in sensible applications

it's selection dependent as a result of form of mango has natural and acceptable variability from one selection to a different.

THEORY OF MULTI ATTRIBUTE DECISION MAKING (MADM)

A Multi Attribute method} (MADM) methodology nominal however attribute info is to be process so as to hit a alternative. It will assign totally different completely different completely different weight to different attributes of the article consistent with different standards to attain the simplification of the multi-attribute issues. The ith alternatives score can be determined with the magnitude of the index P_i ($i = 1, 2, \dots, m$):

$$P_i = \sum_{j=1}^n w_j (m_{ij})_{\text{normal}} \quad (5)$$

where, w_j is that the weight of the attribution j , $(m_{ij})_{\text{normal}}$ represents the normalized price of m_{ij} of the attribution j of alternatives i , n is that the variety of indices. Considering the total of all weights equals to one i.e., $w_1 + w_2 + w_3 = \text{one}$. And p_i is that the overall or composite score of the choice A_i . Normally, the index (size, form and surface defects) conflicts with each other throughout multi-indices grading. as an example, therefore mangoes have giant sizes however their surface is flawed soon have associate degree influence once they area unit placed along. to unravel these issues, Multi Attribute deciding (MADM) theory is adopted during this system. It will assign totally different completely different completely different weights to different attributes of the article consistent with different standards to attain the simplification of the multi-attribute issues.

THEORY OF FUZZY ALGORITHM

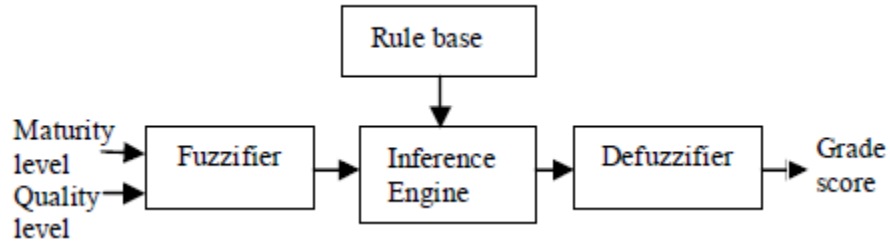
Fuzzy Inference System (FIS) based on Takagi-Sugeno model, where the antecedents are fuzzy and the consequent is crisp. The two inputs of FIS, maturity level and quality level are first fuzzified into a fuzzy set. The fuzzy model proposed is widely used for generating rules using input-output data. A practical application of kernel-based

fuzzy discriminant analysis and feature extraction using fuzzy maximum margin criterion is discussed. We have two data points that corresponds to normalized value of maturity level and quality level. The set of input-output data pairs is given as follows:

$$(x_1^{(i)}, x_2^{(i)}; g^{(i)}).$$

Here $x_1^{(i)}$ and $x_2^{(i)}$ are the normalized values of inputs, and $g^{(i)}$ is the output of i^{th} mango sample. Here we generated set of fuzzy rules using different steps [35] from the above data and used these fuzzy rules to determine mapping

$$f: (x_1, x_2) \rightarrow g.$$



4.5- Fuzzy Inference System (FIS)

Rules obtained from each pair of input-output data as:

$$R_i = IF \ x_1^{(i)} \text{ is } r_a(\mu_{r_a}^{(i)}) \text{ and } x_2^{(i)} \text{ is } r_b(\mu_{r_b}^{(i)}) \\ THEN \ g^{(i)} \text{ is } r_c(\mu_{r_c}^{(i)}) \quad (6)$$

Where R_i is the i^{th} rule, r_a and r_b are the fuzzy sets representing different regions of the input space, r_c is the fuzzy set representing the region in the output space, and $u^{(i)}$'s are the corresponding membership values. In each rule, there are two atomic clauses in the antecedent part. Centroid defuzzification method is used to determine the output grade

g for given input x_1 and x_2 . The fuzzy training and testing algorithm used for mango grading.

To developed membership function of output, the range of output category was determined by considering all range of Red, Green and Blue for each linguistic term and described in Table below.

Linguistic term	Range
Ripe	0 to 0.3
Unripe	Greater than 0.8
Overripe or rotten	0.3 to 0.8

The Range Value of Linguistic Variable for Output Category

In order to develop the rule, we refer to table 1 above and some of fuzzy inference rules are designed as follows.

Rule 1: IF (Red is Low) AND (Green is High) AND (Blue is Medium) THEN Unripe

Rule 2: IF (Red is Medium) AND (Green is Medium) AND (Blue is Medium) THEN Ripe

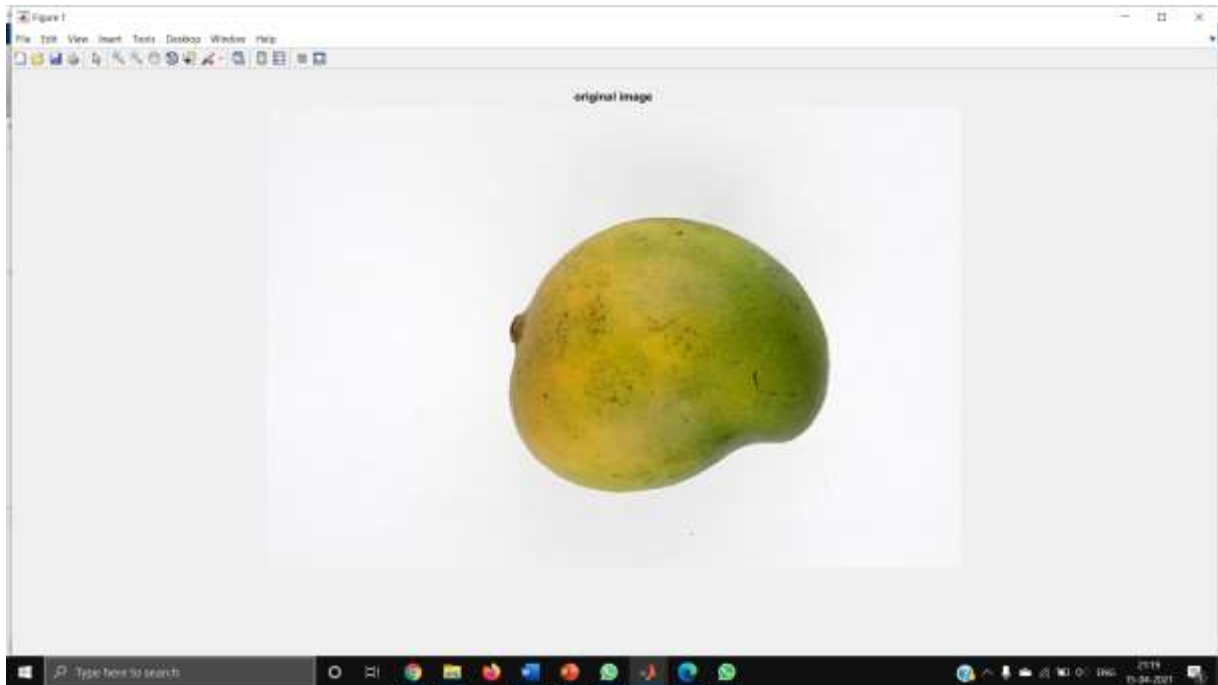
Rule 3: IF (Red is High) AND (Green is Low) AND (Blue is Low) THEN Over Ripe

Fuzzy Logic Prediction						
	Mango Grade	Under ripe	Ripe	Over ripe	No of mango used	Correctly classified mango
Human expert	Under ripe	5	0	0	5	100%
	Ripe	0	5	0	5	100%
	Over ripe	0	0	5	5	100%
Total		5	5	5	15	
Observed (%)		100%	100%	100%		100%

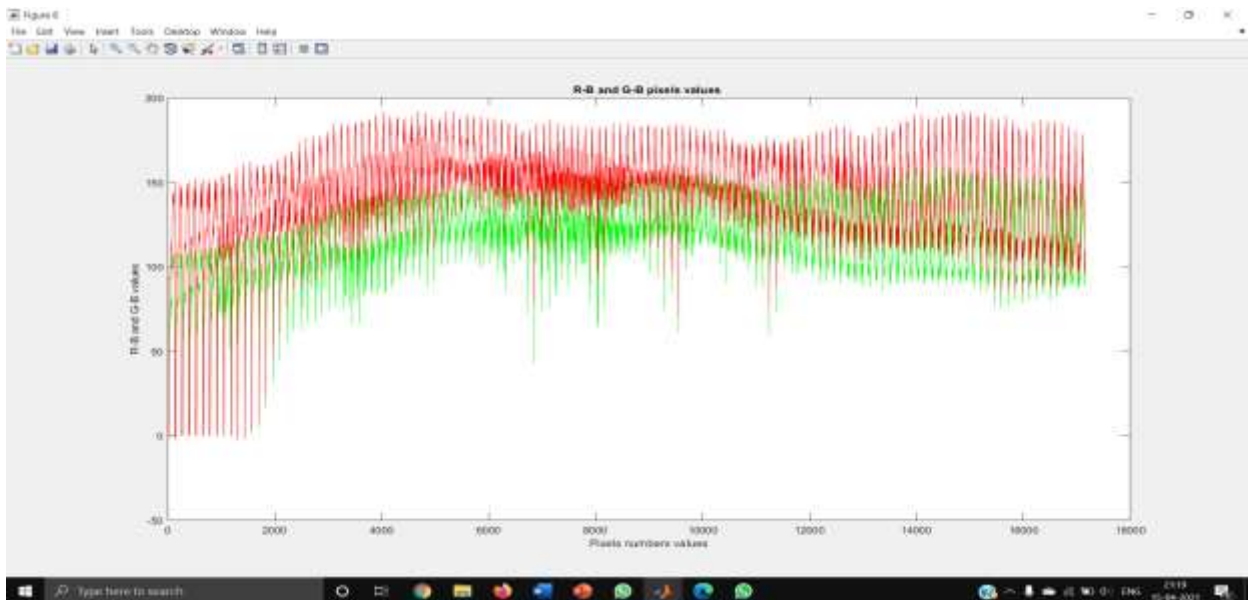
Comparison of Proposed Fuzzy System and Human Expert in Grading of Mango

The better or good range for each colour needs to be obtained in order to improve the grading system performance. The fuzzy rules need to be added or improved especially for the fruit that lies closely between two different categories and the additional feature that incorporate differences between the categories such as texture need to be added. The results of the fuzzy logic system evaluated are against the human graders method to measure the accuracy for mango ripening index. Based on the results in Table 6, our proposed model has increased the accuracy of grading by as much as 100%. This shows that the grading system using fuzzy logic has a high potential of accurateness in grading the mango fruit

Sample Output of image of grade-1

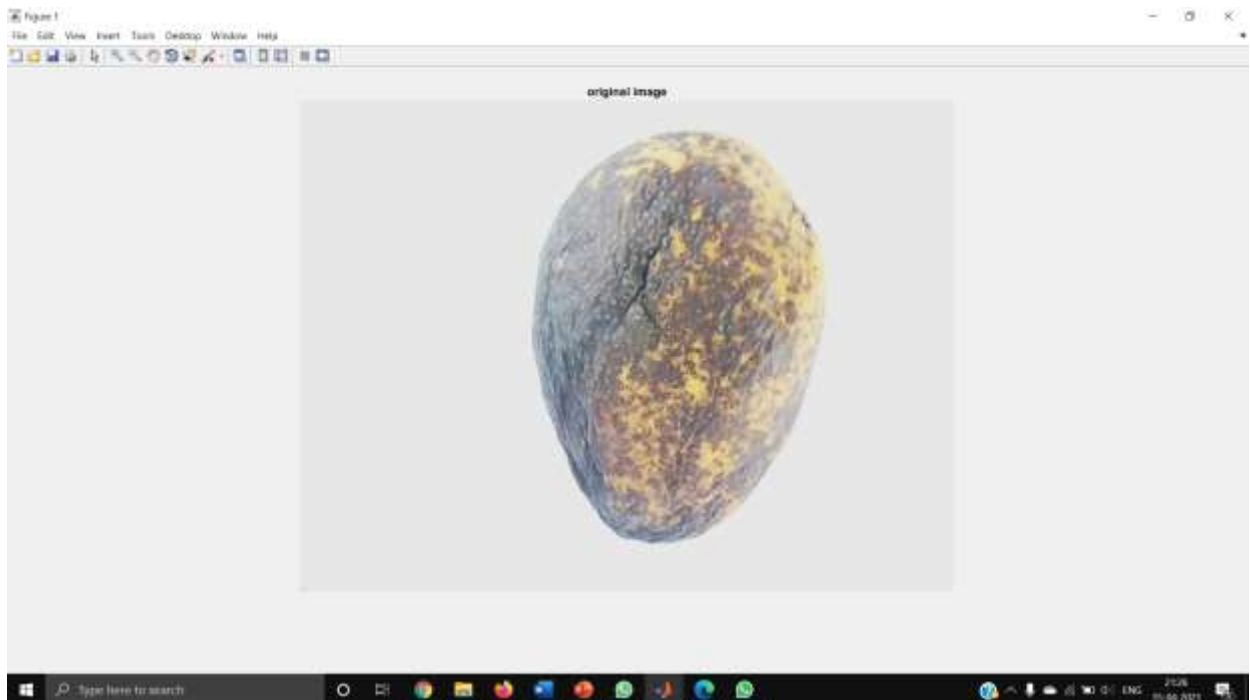


Original Image of grade-1 mango

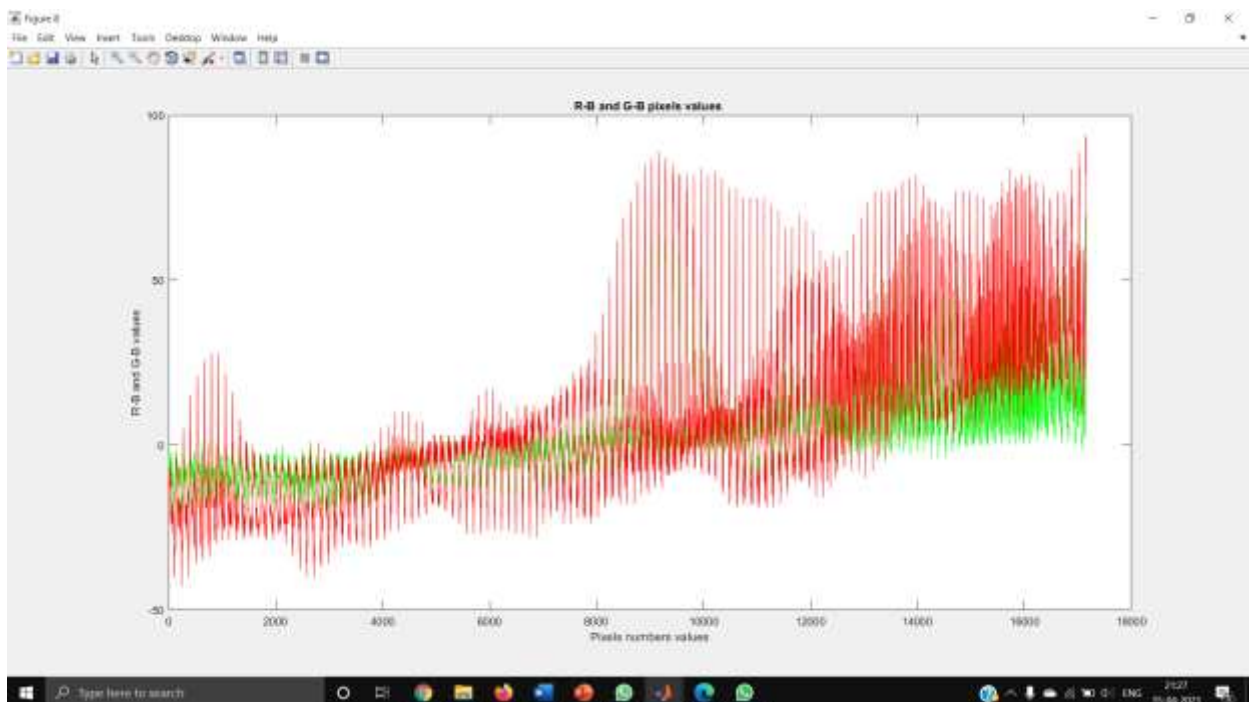


R-B and G-B pixels values

Sample Output of image of grade-3



Original Image of grade-1 mango



R-B and G-B pixels values

4.6- DATABASE

S.No	Type of Mango	Mango
1	Ripe (Grade 1)	
2	Ripe (Grade 1)	
3	Ripe (Grade 1)	
4	Ripe (Grade 1)	
5	Ripe (Grade 1)	

S.No	Type of Mango	Mango
6	Unripe (Grade 2)	
7	Unripe (Grade 2)	
8	Unripe (Grade 2)	
9	Unripe (Grade 2)	
10	Unripe (Grade 2)	

S.No	Type of Mango	Mango
11	Over ripe / diseased (Grade 3)	
12	Over ripe / diseased (Grade 3)	
13	Over ripe / diseased (Grade 3)	
14	Over ripe / diseased (Grade 3)	
15	Over ripe / diseased (Grade 3)	

SOFTWARE USED

MATLAB SOFTWARE DETAILS

MATLAB is a high-performance language used for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in mathematical notation.

Typical uses include:

- Math and computation
- Algorithm development
- Modeling, simulation, and prototyping
- Data analysis, exploration, and visualization
- Scientific and engineering graphics
- Application development, including Graphical User Interface building
- An interactive numerical computing environment
- Matrix computations, Graphics and Programming (M-files)
- Toolboxes (signal processing, statistics, optimization, symbolic math)

MATLAB is an interactive system whose basic information component is an array that doesn't need orientating. This permits you to unravel several technical computing issues, particularly those with matrix and vector formulations, in a very fraction of the time it might go for write a program in a very scalar non-interactive language like C or FORTRAN.

The name MATLAB stands for matrix laboratory. MATLAB was originally written to supply easy accessibility to matrix code developed by the LINPACK and EISPACK codes, that along represent the progressive in code for matrix computation.

MATLAB has evolved over a amount of years with input from several users. In university environments, it's the quality tutorial tool for introductory and advanced

courses in arithmetic, engineering, and science. In trade, MATLAB is that the tool of selection for high-productivity analysis, development, and analysis.

MATLAB options a family of application-specific solutions known as toolboxes. important to most users of MATLAB, toolboxes enable you to find out and apply specialised technology. Toolboxes area unit comprehensive collections of MATLAB functions (M-files) that stretch the MATLAB atmosphere to unravel explicit categories of issues. Areas within which toolboxes area unit obtainable embody signal process, management systems, neural networks, mathematical logic, wavelets, simulation, and plenty of others.

Matlab (matrix laboratory) may be a numerical computing atmosphere and fourth-generation programming language. developed by math-works, matlab permits matrix manipulations, plotting of functions and information, implementation of algorithms, creation of user interfaces, and interfacing with programs written in alternative languages, together with c, c++, java, and FORTRAN.

Although MATLAB is meant primarily for numerical computing, associate degree nonobligatory tool cabinet uses the mupad symbolic engine, permitting access to symbolic computing capabilities. an extra package, simulink, adds graphical multi-domain simulation and model-based style for dynamic and embedded systems.

In 2004, matlab had around one thousand thousand users across trade and academe. Matlab users come back from numerous backgrounds of engineering, science, and political economy. Matlab is wide utilized in tutorial and analysis establishments additionally as industrial enterprises.

These factors build MATLAB a wonderful tool for teaching and analysis. MATLAB has several blessings compared to traditional pc languages (e.g., C, FORTRAN) for determination technical issues. MATLAB is associate degree interactive system whose basic information component is associate degree array that doesn't need orientating. The code package has been commercially obtainable since 1984 and is currently thought of as a customary tool at the most universities and industries worldwide. it's

powerful constitutional routines that change a awfully big variety of computations. It additionally has simple to use graphics commands that build the visual image of results right away obtainable. Specific applications area unit collected in packages noted as tool cabinet. There area unit toolboxes for signal process, symbolic computation, management theory, simulation, improvement, {and several}and a number of alternative|and several other} other fields of field and engineering.

Matlab with Simulink building a dynamic model will truly be fun. it's additionally powerful enough to try to to real work, once you learn a number of its advanced options (i.e., it's not a waste of your time to learn). In fact, we are going to solely use a number of the rather basic options of Simulink for the models we tend to build, and you're free (and encouraged) to explore another options which will assist you with issues you would like to unravel. Basically, you'll consider a Simulink model as like describing a schematic drawing of your system, wherever the variables flow on wires and area unit modified, or remodeled, by numerous devices. Let's build a Simulink model for the linear spring-mass system with viscous damping: initial, you would like to begin the mat research lab application, that you are doing in UNIX by writing "Matlab" at the shell prompt, or in Windows by double-clicking (rapidly clicking the left push twice) on the Matlab icon, that you'll notice buried somewhere with a bunch of alternative icons. this can get you to the ">>" Matlab prompt. kind "Simulink" to begin Simulink, and convey up the most Simulink window (your windows might look somewhat completely different, counting on the machine and in operation system): Let's bear the fundamental functions of this window initial.

On high may be a list of things that area unit related to pull-down menus. These are going to be duplicated on your model space (see below), therefore for the foremost half they're not too vital here. Exept for the "file" menu, that you'll use to make a replacement model space or to cite a file browser to access associate degree existing (saved) model. every of the block icons correspond to a class of transformations which will be wont to describe the dynamic system. you'll largely use the transformations represented in "Sources," "Sinks," "Linear," "Nonlinear," and "Connections." The "Sources" icon contains a set of signal generators, like random variety generators and wave (sinusoidal, square, etc.)

generators, which will be wont to give time-varying inputs that drive your dynamic system (these area unit exogenous inputs, or external inputs, that means that their dynamics area unit represented outwardly to the model). The "Sinks" class can chiefly be wont to access the "Scope" and graphs to that you'll connect the system "wires" to induce a "readout." The "Linear" class contains all the potential ways that to rework a variable linearly, like differing types of gains. It additionally has the fundamental "integrator" block that we are going to use extensively to model our first-order dynamic systems

Starting MATLAB

After logging into your account, you can enter MATLAB by double-clicking on the MATLAB shortcut icon on your Windows desktop. When you start MATLAB, a special window referred to as MATLAB desktop appears. The desktop is a window that contains other windows. The major windows within the desktop are The Command Window, The Workspace, The Current Directory, The Help Browser, The Start button.

This illustration additionally shows the default configuration of the MATLAB desktop. you'll be able to customise the arrangement of tools and documents to fit your desires. Now, we tend to have an interest in doing a little straightforward calculation. we'll assume that you just have comfortable underneath standing of your pc under that MATLAB is being run.

Correcting and ending debugging

While debugging, we are able to amendment worth the worth of a variable to envision if the new value produces expected results. whereas the program is paused, assign a brand-new worth to the variable within the Command Window, space browser, or Array Editor. Then continue running and stepping through the program.

Ending debugging

After distinguishing a drag, finish the debugging session. it's best to quit rectify mode before writing AN M-file. Otherwise, you'll get sudden results once you run the file. to finish debugging, choose Exit rectify Mode from the rectify menu. Correcting an M-file

To correct errors in an M-file,

- Quit debugging
- Never make changes to an M-file while MATLAB is in debug mode
- Make changes to the MATLAB file
- Save the changes in M-file
- Clear the breakpoints
- Rerun the MATLAB file again to ensure it gives the expected results

Benefits of MATLAB

- Error Elimination can be done early in the design
- powerful control system
- Less iteration in the development cycle, reduced time and cost of development, etc.
- Moreover, in real-time these tools can be integrated with hardware which means integrating traditional off-line simulation with real-world testing.
- A simplified procedure that absolves a designer from encoding his mathematical model in the programming language adopted.
- a possibility of a multiple use of the basic mathematical models, gathered at the libraries and combined as needed.

The MATLAB System

The MATLAB system consists of five main parts:

The MATLAB language

This is a high-level matrix/array language with management flow statements, functions, knowledge structures, input/output, and object-oriented programming options. It permits each "programming within the small" produce fast and dirty throw-away programs, and "programming within the giant" to make complete large and complicated application programs.

The MATLAB working environment

This is the set of tools and facilities that you simply work with because the MATLAB user or computer user. It includes facilities for managing the variables in your space and importation and mercantilism knowledge. It additionally includes tools for developing, managing, debugging, and identification M-files, MATLAB's applications.

Handle Graphics

This is the MATLAB graphics system. It includes high-level commands for two-dimensional and three-dimensional knowledge visual image, image process, animation, and presentation graphics. It additionally includes low-level commands that permit you to completely customise the looks of graphics additionally on build complete Graphical User Interfaces on your MATLAB applications.

The MATLAB mathematical function library

This is a vast collection of computational procedure algorithms starting from elementary functions like add, sine, cosine, and complicated arithmetic, to additional refined functions like matrix inverse, matrix eigenvalues, Friedrich Wilhelm Bessel functions, and quick Fourier transforms.

The MATLAB Application Program Interface (API)

This is a library that enables you to jot down C and algebraic language programs that act with MATLAB. It embodies facilities for line routines from MATLAB (dynamic linking), line MATLAB as a procedure engine, and for reading and writing MAT-files.

Starting MATLAB

After logging into your account you'll open MATLAB by double-clicking on the MATLAB icon (MATLAB 2018a) on your computer desktop. After you begin MATLAB, a special window seems named the MATLAB desktop. It is a window that contains alternative windows. The key tools that are unit accessible from the MATLAB desktop area are The Command Window, The Command History, The Workspace, The Current Directory, The Help Browser, The Start button.

Syntax

The MATLAB application is made round the MATLAB scripting language. Common usage of the MATLAB application involves victimisation the Command Window as associate interactive mathematical shell or execution text files containing MATLAB code.

Structures

MATLAB has structure knowledge varieties. Since all variables in MATLAB are unit arrays, an additional adequate name is "structure array", wherever every part of the array has an equivalent field names. Additionally, MATLAB supports dynamic field names (field look-ups by name, field manipulations, etc.). Sadly, MATLAB JIT doesn't support MATLAB structures, so simply a straightforward bundling of assorted variables into a structure can come back at a value.

Functions

When making a MATLAB function perform, the name of the file ought to match the name of the primary perform within the file. Valid perform names begin with associate character, and may contain letters, numbers, or underscores.

Function handles

MATLAB supports parts of lambda calculus by introducing the perform handles or the perform references, that area unit enforced either in “.m” files or anonymous/nested functions.

Classes and object-oriented programming

MATLAB supports the idea of object-oriented programming includes categories, inheritance, virtual dispatch, packages, class and object, pass-by-value linguistics and pass-by-reference linguistics. However, the syntax and job conventions area unit considerably totally different from alternative programming languages. MATLAB has different price categories and reference categories, looking on whether or not the category has handle as a super-class.

APPLICATIONS OF MATLAB:

- Mathematical Calculations
- Data Analysis & Visualization
- Software Development
- Simulation
- Signal processing

ADVANTAGES:

- It is a beginner friendly computer programming language.
- It comes with well-documented manuals.
- Large user community, sharing free codes. It enables you to add Matrices simply. It enables you to do some difficult calculations quickly, while not having to jot down an entire program or computer program. a lot of add-ons and workbenches obtainable to try and do a range of tasks.
- Easy, interactive setup environment
- Fast numerical algorithms
- Inexpensive software

CHAPTER 5

SUMMARY AND CONCLUSION

CONCLUSION

The image analysis using fuzzy logic is implemented for grading of the mangoes according to their quality. This process is majorly divided into two parts in the initial phase the image is processed digitally and different types of algorithms and is further classified into three different grades. In the next part involves the classification system using the fuzzy inference systems. The involvement of the human labour can be decreased by implementing this method successfully. In this process MATLAB language is used and fitting for several unpredictability.

By combining the results obtained by digital processing of image and fuzzy inference systems the mangos are classified according to the final results. In order to obtain the various physical features of the mango using digital processing of the image in MATLAB. The output obtained by the above method is given as input to fuzzy logic.

The steps followed by the software system is it extracts a single frame from the video image, then the image goes through a series of pre processing techniques and finally it is sent to fuzzy inference system for grading and classification of the mango. From the obtained results by the algorithm it shows that the algorithm predicts the mangoes accurately. Therefore, the successful application of fuzzy logic in classification of mango as a technique for making decisions is obtained.

REFERENCES

1. J. Brezmes, Ma. L. L. Fructuoso, E. Llobet, X. Vilanova, I. Recasens, J. Orts, G. Saiz, and X. Correig, "Evaluation of an electronic nose to assess fruit ripeness," *IEEE Sensors Journal*, vol. 5, no. 1, pp. 97-108, Feb. 2005.
2. A. G. Mignani et al., "EAT-by-LIGHT: Fiber-optic and micro-optic devices for food quality and safety assessment," *IEEE Sensors Journal*, vol. 8, no. 7, pp. 1342–1354, Jul. 2008.
3. M. Stefania, D. Marco, M. Rossano, C. Giovanni, and R. Damiano, "A Spectroscopy-Based Approach for Automated Nondestructive Maturity Grading of Peach Fruits," *IEEE Sensors Journal*, vol. 15, no. 10, pp. 5455-5464, Oct. 2015.
4. G.Q. Jiang, C. J. Zhao, Y. S. Si, "A machine vision-based crop rows detection for agricultural robots," *IEEE Int. Conf. on Wavelet Analysis and Pattern Recognition (ICWAPR)*, Qingdao, 11-14 July 2010, pp. 114 – 118. 7
5. J. Hays and A. Efros. Large-Scale Image Geolocalization. In J. Choi and G. Friedland, editors, *Multimodal Location Estimation of Videos and Images*. Springer, 2014, 6
6. J. Huang, V. Rathod, C. Sun, M. Zhu, A. Korattikara, A. Fathi, I. Fischer, Z. Wojna, Y. Song, S. Guadarrama, et al. Speed/accuracy trade-offs for modern convolutional object detectors. 2016. 7
7. J. Salamon and J. P. Bello, "Deep convolutional neural networks and data augmentation for environmental sound classification," *IEEE Signal Processing Letters*, vol. 24, no. 3, 2017. 279,283
8. K. He, X. Zhang, S. Ren, and J. Sun. Deep residual learning for image recognition, 2015. 1
9. McLoughlin I, Zhang H, Xie Z, Song Y, Xiao W, et al. Continuous robust sound event classification using time-frequency features and deep learning. 2017, 49,61

10. M. Courbariaux, J.-P. David, and Y. Bengio. Training deep neural networks with low precision multiplications. 2014. 2
11. O. Houix, G. Lemaitre, N. Misdariis, P. Susini, and I. Urdapilleta, “A lexical analysis of environmental sound categories.” *Journal of Experimental Psychology: Applied*, vol. 18, no. 1, 2012.pp. 279–283
12. S. Han, H. Mao, and W. J. Dally. Deep compression: Compressing deep neural network with pruning, trained quantization and huffman coding. *CoRR*, 2015. 2
13. S. Ioffe and C. Szegedy. Batch normalization: Accelerating deep network training by reducing internal covariate shift., 2015. 1, 3, 7
14. W. Chen, J. T. Wilson, S. Tyree, K. Q. Weinberger, and Y. Chen. Compressing neural networks with the hashing trick., 2015. 2