Assessment of Fruit Maturity using Digital Image Processing

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Abstract

In recent years automatic vision based technology has become more powerful and more efficient to many areas including agricultural fields and food industry. An automatic vision based system for sorting and grading offruit like cherry and strawberry based on their maturity level discussed here. The most common property to measure quality of any fruit is its appearance which includes colour, shape, size and surface conditions. The analysis of colour is especially an important consideration when determining the efficiency of fruit. This study used an inexpensive method to predict cherry and strawberry color parameters by combining image processing and artificial neural network (ANN) technique. The automatic vision based technology consisted of a CCD camera for image acquisition, MATLAB software for image analysis and ANN for modeling.

Keywords: cherry and strawberry fruit, image processing, ANN modeling

I. INTRODUCTION

In most developing nations such as India, agriculture forms the major part of the country's economy. It is due to this fact that a lot of money is spent each year by governments across the world, for utilizing new technologies, bring to light new methodologies of farming. It is a well-known fact that the production of a good quality afford not only benefits consumers, who pre-eminent form the top end of the food chain, but also economically benefits the farmer who work hard to produce good yield. In a farmer's aspects, the better the quality, the more the income, since agricultural produce is not only used for direct consumption by people but also by the food industry, which use the same for the manufacture of several products. During season, fruits are collected from trees in bundles, and then sorted according to maturity level for transportation to different locations.

Cherry and strawberry harvested from various trees in a lot are not uniformly matured, thus classifying according to the maturity level is necessary, as transportation times for different locations are different. In general, classification most of the matured fruits must be sold to market places and most of the pre-matured fruits can be shipped to customers over much greater distances.

Cherry and strawberry fruits play vital role in human diet from nutritional points of view. This fruit helps the body to fight against cancer. Cherry and strawberry provides us with the perfect amount of calories required for heath. This fruits that are a rich source of vitamins and minerals. Fruit maturity has a major influence on fruit quality which is determined by biochemical and structural changes occurring during fruit ripening.

Climacteric fruits such as cherry and strawberry fruits can be harvested when mature and ripened off the plant. Fruit maturity stage at harvest determines the basic fruit quality and shelf-life which is essential to consecutive fruit sorting towards different distribution channels. However, it is difficult to identify a harvesting time that represents the best pass judgment between consumer-oriented and commercial qualities. A fruit that is harvested when is fully ripe has better organoleptic properties but has a shorter shelf-life being ready to eat and thus more adaptable to softening and decay. Contrarily, fruits early-harvested when mature or under-mature have an increased shelf-life and may undergo longer post-harvest handling chains.

Now-a-day, most farms use manual experts for classification of the fruits, but as most of the fruits are seasonal, so getting sufficient number of manual experts during the period are very difficult. On the other hand, manual classification of different fruit is laborious, time consuming, annoying and suffering the problem of inconsistency and inaccuracy in judgment by different human experts. Therefore, the scope of this paper is to develop an automatic vision based technology, for automatic classification of cherry and strawberry fruit into different ripening stages, by predicting the number of days
Left before the cherry and strawberry gets over matured or rotten.

II. RELATED WORK

From the study on various types of techniques provides by different authors for maturity prediction some of them are illustrated as below, Literature survey includes various techniques and work done related to maturity of different fruit Dah-Jye Lee[1], proposed a new color mapping concept of converting 3-D color spaces to 1-D color indices for automated color grading. In this paper, they present an effective and user-friendly color mapping concept for automated color grading that is well suited for

commercial production. This color mapping method assigns colors of interest specific to a given application to calculate a unique set of coefficients for color space conversion**.**

S.Taghadomi-Saberi1, M. Omid, Z. Emam-Djomeh, and Kh. Faraji-Mahyari[2], This paper describes a novel methodology to demonstrate the usefulness of this technique, changes of cherry color during ripening were studied. After designing, training, and generalizing several ANNs using Levenberg-Marquardt algorithm, a network with 7-14-11-3 architecture showed the best correlation for *L**, *a** and *b** values in which *L** and *b** parameters decreased during ripening of cherries and *a** parameter increased at first and then decreased. Using above logic the ripeness level of cherry determined.

Sudhir Rao Rupanagudi, Ranjani B.S., Prathik Nagaraj, Varsha G Bhat[3**]**, In this paper the cost effective maturity grading system for one of the most popular fruit tomato was done using a novel setup utilizing inexpensive material and image processing algorithms to identify the six important stages of tomato ripening had been presented. All algorithms were first designed and developed using Simulink, a part of MATLAB on a 2.5 GHz CPU with an overall 98% accuracy was achieved.

Meenu Dadwal, V.K.Banga[4] **,** In this paper, two techniques had been used which are color image segmentation and fuzzy logic technique. Four images of a single fruit had been captured from four different directions and separate desired part from each image using color image segmentation. calculate the RGB value segmented part and gave input to fuzzy logic editor1, fuzzy logic gives output whether the fruit ripe or not. The same logic applied for remaining 3 fruit, these 4 input were applied to fuzzy logic editor2 which states whether the fruit ripe, over-ripe or not.

Kamalpreet Kaur, Preeti Gulati[5], they develop a new and efficient algorithm for identify the quality of fruits. In this paper fruit quality extraction in terms of its shape, size and ripen stage, Fruit stage with respect to any disease, Penetration of disease into the fruit and Final fruit quality was done.

Chandra Sekhar Nandi, Bipan Tudu, and Chiranjib Koley[6], The prediction of maturity level has been performed from the video signal collected by the CCD camera placed on the top of the conveyer belt carrying mangoes. Segmented image frames from the video signal have been corrected and processed to extract various features, which were found to be more relevant for the prediction of maturity level. Recursive feature elimination technique in combination with SVM based classifier has been employed to identify the most relevant features among the initially chosen 27 features. lastly, the optimum set of reduced number of features have been obtained and used for sorting of the mangoes into four different classes according to the maturity level from least mature to over mature.

Stefania Matteoli, Marco Diani,Rossano Massai, Giovanni Corsini[7], This paper presents an automated way for peach fruit maturity grading by exploiting fiber-optic spectroscopy-based sensors and multivariate processing techniques, which minimizes the operator intervention while reducing discharge and waste. The use of a spectroscopic sensor complies with the so called non-destructive measurement method. This method enables fast repeated measurements to be performed at the single fruit level while avoiding fruit damage and loss.

Alok Mishra, Pallavi Asthana, Pooja Khanna[8], This paper illustrare the identification of fruits based on quality in the food industry which is the most important technology in the realization of automatic fruit sorting in order to reduce the work of human and time consuming. This work presents a hierarchical grading method applied to the fruits, in this work the identification of good and bad fruits is focused on the methods using MATLAB. First extract certain features from the input fruit image, later using different method like thresholding, segmentation, k-means clustering. From the proposed range identification can be done, the good and bad fruits. Thus this paper gives the good and bad fruits with a very high accuracy successfully using image processing.

Z. May, M. H. Amaran[9], This paper deals with the development of an automated ripeness assessment of oil palm fruit using RGB color model and fuzzy logic technique. The different classes of oil palm fruit considered are under ripe, ripe and overripe. The ripeness of the fruit is based on different color intensity and size. This system uses a computer, a CCD camera and MATLAB software to analyze it and interpret output images. The simulation results demonstrate the ability in distinguishing the different classes of oil palm fruit automatically with overall efficiency of 88.74%.

Navnee S. Ukirade(11), To improve image quality the collected images are converted to color space format (HSV). A Back propagation neural network used to perform classification of tomato maturity based on color. Matlab software and its image processing toolbox have been used in this analysis.

III. METHODOLOGY

A. Block Diagram:

For this paper, the cherry and strawberry of different locality were collected; to determine the maturity of the fruit we follow the method one by one as shown in below block diagram. In this we first take an RGB input of fruit. After then divide this into R channel and G channel which further converted to R mask and G mask images of fruit. Taking intermediate mask from the R mask and G mask then using this intermediate mask different feature vectors were calculated. Classification was done into four stages which are

1) Pre-mature fruit
2) Early-mature fruit
3) Mature fruit
4) Over-mature fruit

After classification 24samples of strawberry and 17samples of cherry had to be trained using b-back-propagation algorithm. Completion of feature training feature testing was done and lastly using the above arrangement decision was taken whether the fruit is mature, early mature, mature or over mature,

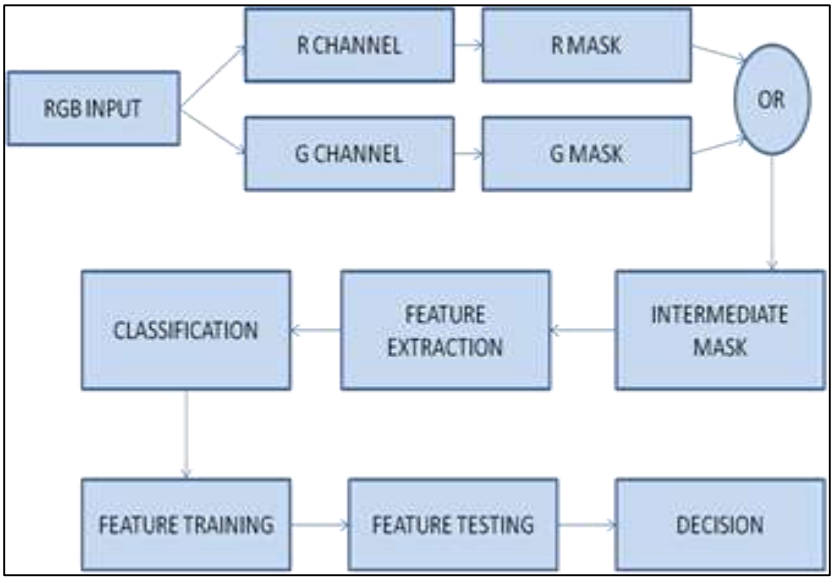


Fig. 3.1: Block Diagram for Maturity of Fruit Detection

B. Acquisition of Fruit Images:

Including the cherry fruit and strawberry fruit data in the form of digital images before processing it is called as acquisition of images which is in the RGB format. To improve the processing speed these images are resized it into proper size of original image. The four samples of strawberry and cherry fruit stages shown in below

Fig. 3.2: Input Image Of Strawberry Fruit

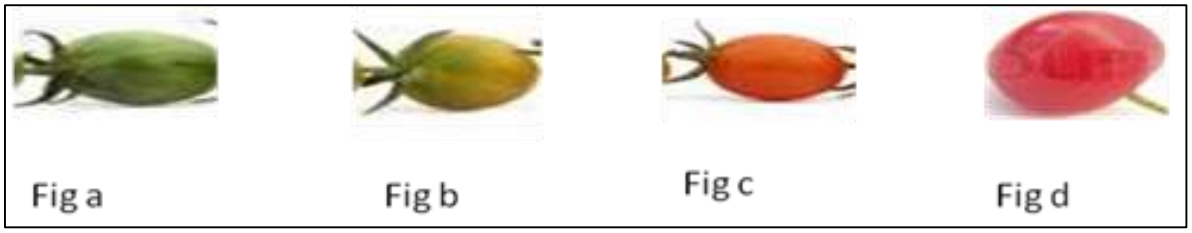


Fig. 3.3: Input Image of Cherry Fruit

A) PRE-MATURE B) EARLY MATURE C) MATURE D) OVER-MATURE

C. Convert to Red Channel:

The RGB color model is an additive color model in which red, green, and blue light are added together in various ways to reproduce a broad array of colors. The name of the modelcomes from the initials of the three primary colors, red, green, and blue. The main purpose of the RGB color model is for the sensing, representation, and display of images in electronic systems, such as televisions and computers, though it has also been used in conventional photography. R channel are separated from the RGB colour images.

D. Convert to Green Channel:

Similarly the G channel also separated from the RGB images of cherry and strawberry fruit.

E. Convert to Red Mask and Blue Mask:

Masks allow hiding part of a layer to display the layer(s) underneath. This gives the ability to adjust and construct in a highly controlled way to create the perfect photo. Masks are entirely non-destructive making them extremely flexible tools. Masks can be edited or deleted at any point in workflow and at any later time.

The blue and red channels are first binarized to generate blue and red masks. For each pixel in the image, the corresponding value in the blue mask is set to 0 if the value of the blue channel is high (blue background), otherwise it is set to 255 (fruit).

F. Intermediate Mask:

First, blue does not occur naturally in strawberry and cherry. Second, blue is one of the three channels in the RGB color space, making it easier to filter than colors that require multiple channels to represent. Fruit is segmented from the blue background by creating masks corresponding to the fruit area using the blue and red channels. The new color mapping method is then used to remove areas of shadow and increase the accuracy of the mask.

Adding the R mask and G mask together, intermediate colour indices is obtained from the blue background by creating masks corresponding to the fruit area using the blue and red channels. The new color mapping method is then used to remove areas of shadow and increase the accuracy of the mask.

Adding the R mask and G mask together, intermediate colour indices is obtained.

G. Feature Extraction:

Feature extraction is defined as gathering the input data objects into a set of features. The features extracted will help to extract the relevant information from the input data in order to perform the feature matching .Using this we can reduce the representation input size instead of the full size input. Here clustering process has been used to extract features form good and bad fruits. The feature analyses of cherry and strawberry include extraction of color features.

In this study, 24 features common in this field were extracted and applied which are given below.

Table – 1

Feature vector of cherry and strawberry fruit

mean	*r _m= Mean(R)*	*g _ m= Mean(G)*	*b _ m= Mean(B)*
normalised	*Rt1=R/(R+G+B)*	*Gt1=G/(R+G+B)*	*Bt1=B/(R+G+B)*
difference	*r_g=R-G*	*r_b=R-B*	*b_g=B-G*
varience	*v_r=Var(R)*	*v_g=Var(G)*	*v_b=Var(B)*
skewness	*skew_r=Skewness(R)*	*skew_g=Skewness(G)*	*skew_b=Skewness(B)*
kurtoisis	*kor_r=Kurtosis(R)*	*kor_g=Kurtosis(G)*	*kor_b=Kurtosis(B)*
mean	*mean_rg=Mean(r _ g)*	*mean_rb=Mean(r _ b)*	*mean_bg=Mean(b _ g)*
varience	*v_rg=Var(r _ g)*	*v_rb=Var(r _ b)*	*v_bg=Var(rb_ g)*

H. Feature Training:

Feature training method includes collection of large number of trained features of clustered values of mature and pre-mature fruits. More number of collecting trained features gives more accuracy. In this method, the number of closest code vectors for each training vector is identified and is stored as the corresponding cluster density. The cluster densities for all training vectors are computed and are sorted according to their maturity stages i.e premature, early mature, mature or over-mature. From the sorted list, cherry and strawberry are identified and grouped as their maturity level. This maturity level is saved and loaded in MATLAB for feature testing.

1)Artificial neural network:

Artificial neural network resembles the characteristic of biological neural network. The ANN is inspired the design and functioning of human brain. Here we are considering multi-layer perceptron model for this project. In this model there are 3 layers. First one is the input layer which is used to take the data and convert it into the numeric form. The second one is the hidden layer which is used for computation process and the last one is the output layer where it gives the output as positive and negative. In this project we are considering four neurons in input layer. First neuron is for pre-mature, second for early mature, third for mature, forth is for over-mature. Firstly we have to train the neural network with the input vectors of each sentence. There are 17 samples of cherry fruit and 26 samples of strawberry fruit which are used to train the neural network and the 17 samples of cherry fruit and 26 samples of strawberry fruit reviews are used for testing.

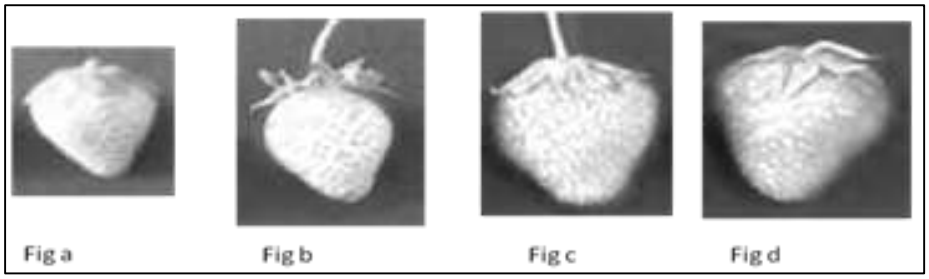
2)Feed Forward Neural Network:

Feed forward neural network is one of the training algorithms which have used to train the neural network. FFNN algorithm is used to minimize the error rate in the neural network. FFNN is used to forward the data through the network until it reaches to the output layer. This forward procedure produces the predicted output. The predicted output is subtracted from the actual output to calculate the error. FFNN used to adjust the weights until the error rate gets minimized. This process carries until the error rate cannot get minimized.

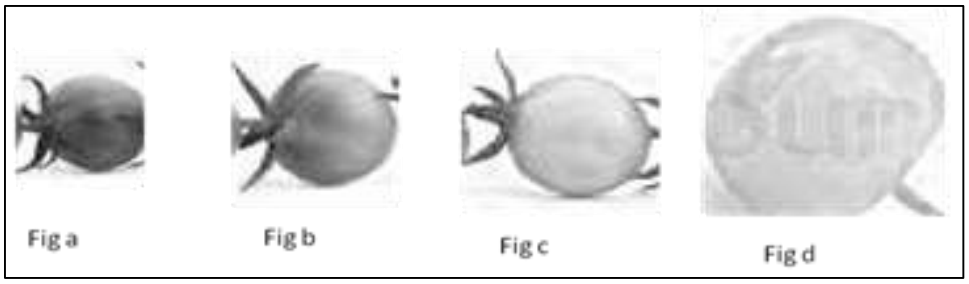
IV. RESULTS

Stepwise analysis of each step with their desired output is shown below.

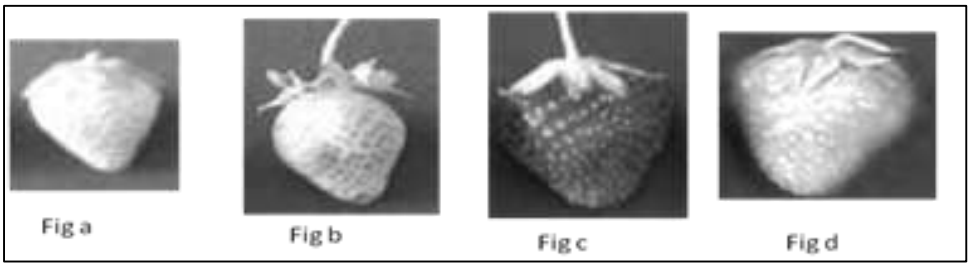
A. R Channel Strawberry Fruit:



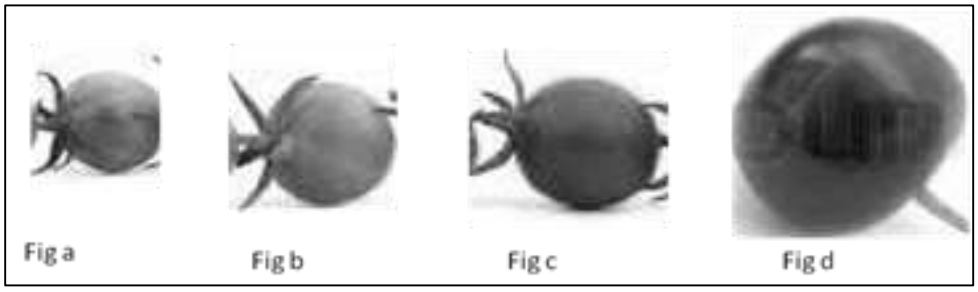
B. R Channel Cherry Fruit:



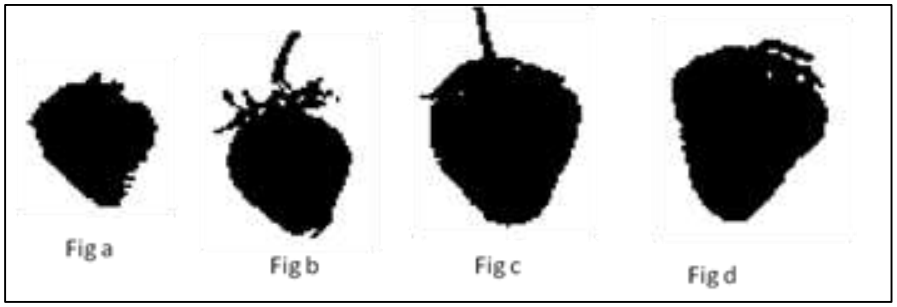
C. G Channel Strawberry Fruit:



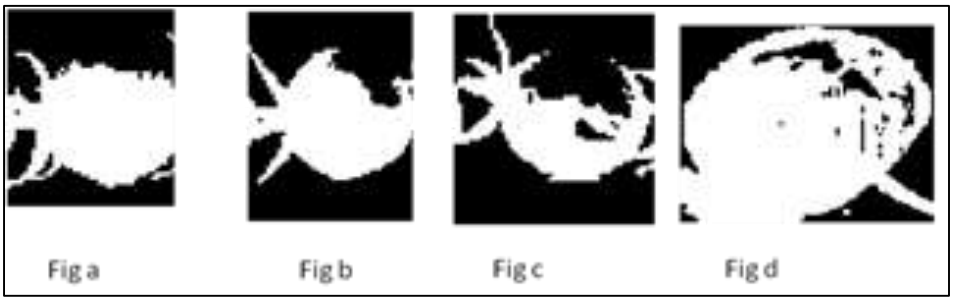
D. G Channel Cherry Fruit:



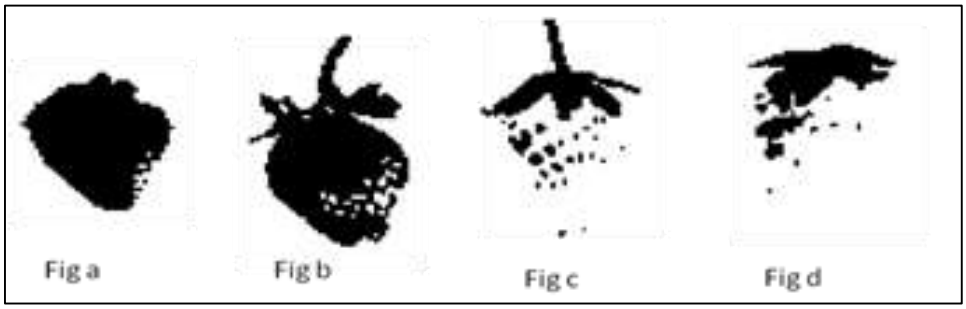
E. R Mask of Strawberry Fruit:



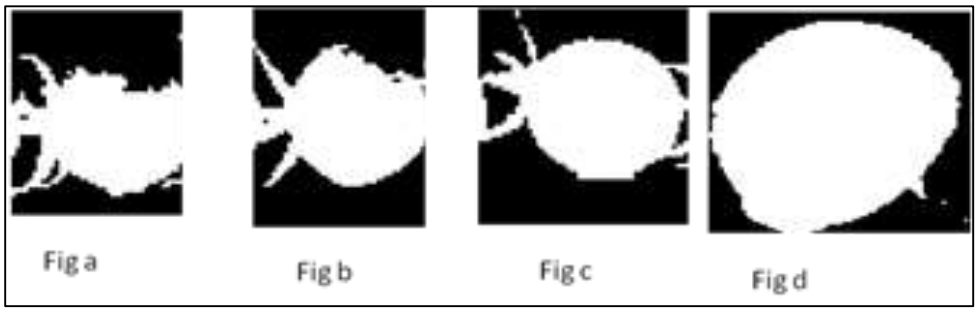
F. R Mask Of cherry Fruit:



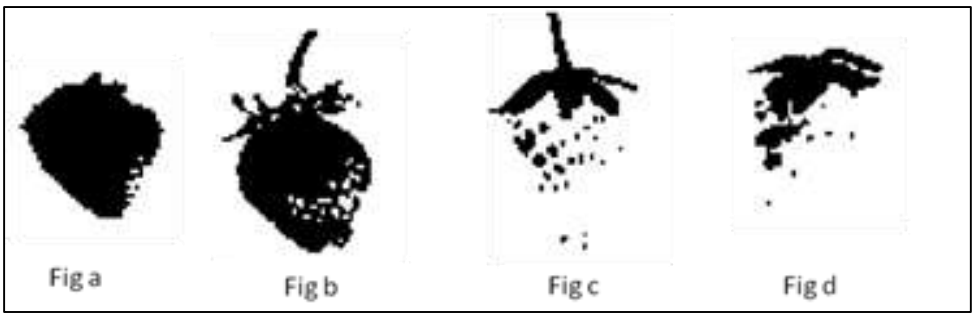
G. G Mask of Strawberry Fruit:



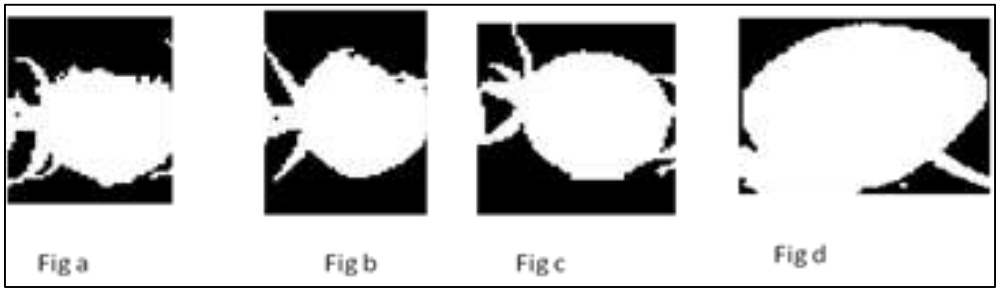
H. G Mask of Cherry Fruit:



I. Intermediate Mask of Strawberry:



J. Intermediate Mask Of cherry:



K. ANN Architecture Used:

- For pre mature cherry and strawberry fruit sample should be equal to 00.
- For early mature cherry and strawberry fruit sample should be equal to 01.
- For mature cherry and strawberry fruit sample should be equal to 10.
- For pre over cherry and strawberry fruit sample should be equal to 11.
- For above the system matches true output otherwise false output

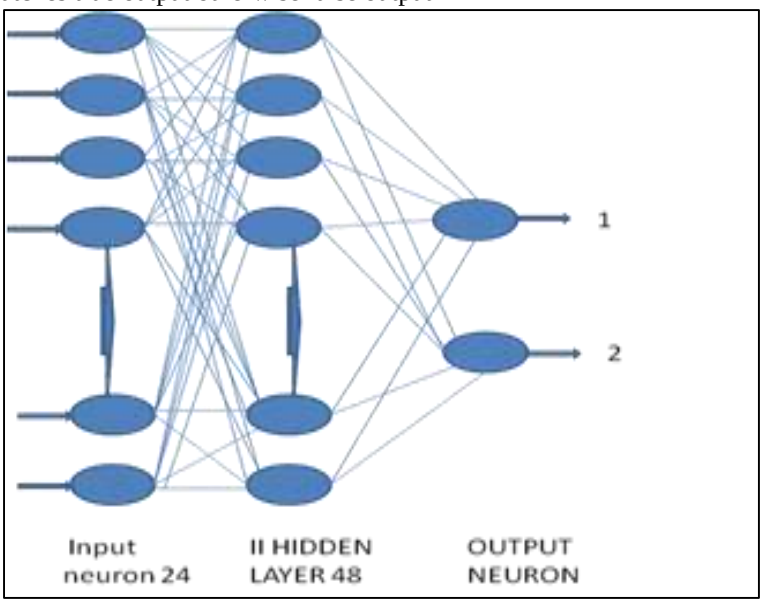


Fig. 4.1: ANN Architecture

Table – 2
Accuracy of Fruit:

TYPE	*TP*	*FP*	*ACCURACY*
CHERRY FRUIT	*11*	*6*	*63%*
STRAWBERRY FRUIT	*15*	*11*	*60%*

ACCURACY= TP/(TP+FP)*100

V. CONCLUSION

In this paper the identification of pre-mature, early-mature, mature and over-mature fruits based on quality in image processing using MATLAB is successfully done with 63% accuracy in cherry fruit and 60% accuracy in strawberry fruit. By using thresholding technique the cherries and strawberry at different stages of ripeness were segmented successfully.

Accuracy of this system with low cost makes it more useful. The color measuring technique discussed in this MATLAB software for image analysis has been used to provide a more versatile way to measure the color of many foods more than the traditional expensive color-measuring instruments

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