

Comparative Study For Fruit Ripeness Classification

Rucha Thakur¹, Gaurav Suryawanshi², Hardik Patel³, Prof. Janhavi Sangoi⁴

¹Department of Computer Engineering, Mumbai University, MUMBAI-68
Email: ruchathakur100@gmail.com

²Department of Computer Engineering, Mumbai University, MUMBAI-68
Email: gavaravsuryavanshi@gmail.com

³Department of Computer Engineering, Mumbai University, MUMBAI-68
Email: hp091234@gmail.com

⁴Department of Computer Engineering, Mumbai University, MUMBAI-68
Email: janhavisangoi@viva-technology.org

Abstract—In recent years, computer vision-based technology is used to acquire, to process, to analyse and to understand digital images, so as to extract necessary information from Images. It has been more efficiently used in various areas including agricultural fields. From the study on various types of techniques provided by the authors for fruit ripeness prediction have shown lower accuracy rate, hence the rate of incorrect predictions are maximum. As strawberries are not only a seasonal fruit but also a cash crop, finding manual experts for classification is a challenging and a costly process. Manual classification is time consuming and economically high, also results in discrete opinions. In this survey, analysis of different approaches to determine the maturity level of strawberry fruit has been carried out. Different approaches have been used for classification of strawberry fruit, also accuracy of each approach is stated respectively.

Keywords—Classification, Computer vision, Neural Network, Image Processing

I. INTRODUCTION

Agriculture forms the major part of India's economy. Due to this fact, an enormous amount of money is spent by the government for utilization of new advanced technologies to prevent destruction and improve the yield of the crops and soil. Flavour and aroma of the fruit are determined by the maturity level of the fruit. This is typically more difficult in case of strawberry as it is a delicate crop. As the amount of strawberry fruits harvested is in large quantities, manually distinguishing them is a difficult job. Therefore, there must be a method to determine the ripeness level of the harvested Strawberry fruit. Selective grading of strawberries is important, so that adequate ripe strawberries reach the vendor or fruit market is required, hence there is an increased need to supply quality Strawberry fruits within a small period of time.

II. LITERATURE SURVEY

K. Raut, et. al. [1] describes the assessment of fruit maturity using digital image processing and ANN. The computer vision-based technology consisted of a Charged Coupled Device camera for image acquisition process and MATLAB software for image analysis. They had done the assessment on the cherry and strawberry fruit, to determine the maturity level of the fruit and initially RGB input was taken, later it will get separated into R and G channel which later get converted into R and G mask. Different feature vectors were obtained. The image categorization was done into four stages that are pre - mature, early-mature, mature and over- mature fruit. The classification of 24 samples of strawberry and 17 samples of cherry was trained using b-black propagation algorithm. After training those feature testing was done and the last decision was taken for maturity. The accuracy of the system for classifying strawberries is 60% and for cherries it is 63%.

A. Krizhevsky, et. al. [2], in the field of image recognition, deep learning methods have been shown to display significant performance improvements compared to shallow learning. As deep learning is represented as a hierarchy of features that is pixel, edges, modules of object, object, group of objects. The architecture built consisted of 8 learned layers, 5 convolutional and 3 fully connected. They showed deep convolutional neural networks has been the most successful algorithm for image

recognition in the field compared to deep Boltzmann machines, convolutional deep belief networks. The dataset named ImageNet provides 15 million labeled images which are of high resolution and belong to roughly 22,000 categories. The images were taken from the internet and were labeled by human labelers using a crowd-sourcing tool named Amazon's Mechanical Turk.

F. Ertam, et. al. [3] proposed a paper describing that as per the proposed system, Convolutional Neural Network (CNN) and SoftMax classifier are used as deep learning artificial neural network. In dataset, there are 60,000 figures for training and 10,000 figures for the test. Each picture consists of 28x28 pixels. It has been observed that the best accuracy is achieved when the ReLu activation function is selected. With the use of ReLu activation function for data classification, 98.43% classification accuracy is obtained on the test data. The increase in the number of iterations showed an increase in the accuracy values, but the total classification time is also increased.

P. Raj Gokul, et. al. [4] proposed a paper describing a method for image processing technique to estimate the volume and maturity of sweet lime. Maturity is determined with the RGB color coding based on RG ratio. Images are processed and their RGB value is determined. B component is set to zero. The ratio between the R and G value is computed for a variety of sweet lime fruits. The RG ratio threshold for ripe fruit and unripe lime is fixed. Hence, can be categorized by maturity level. Maturity of sweet lime is not always dependent on its surface color as there is a probability of lime to be ripe from inside and not show its color outside but for strawberry fruit surface color represents ripeness.

Qingmei Xiao, Wendi Niu, Hong Zhang, et. al. [6] have proposed a system to predict maturity of the tomato based on the surface color. The paper concludes that the surface color of the tomato depicts the maturity level of the fruit. The system used is based on fuzzy theory which is used widely. One of its subclasses of fuzzy theory is fuzzy recognition. The process starts by detecting a single tomato through boundary detection. Maturity level determination is based on the hue values and red areas which are derived from the signal tomato image. The system extracts two features for tomato maturity level recognition, which is red areas and hue of the tomato fruit. Initially the membership functions of the two fuzzy features is defined according to the expert in this area. Hence, five maturity recognition classes based on every feature is calculated. They have calculated all possible recognition class membership functions and have selected the class having the maximum membership. The selected class is the one which was recognized.

Aviso, M. J. A., Cabao-an, A. M. S., Niverba, N. A. P., & Anacan, R. M, [7], have proposed a system to identify the age of the tomato fruit using Image processing. The system uses Image Processing in LabVIEW, to detect the dominant color of the tomato ranging from Green, Orange, and Red and provide the age of the tomato to determine whether it is the correct age for picking. The system is developed as a segregation system to analyse the tomatoes based on color image analysis. The process starts by providing an input image and converting from RGB to HSV, through testing determining the class. The system proposed is limited only to the surface color of the tomato to determine the maturity, but the maturity might be influenced by weather conditions too.

Rupanagudi, S. R., Ranjani, B. S., Nagaraj, P., & Bhat, V. G. [8], have designed a cost effective system to determine the maturity level of tomato using the image processing technique. The system set up consists of a camera placed 46 cm away from the tomato to be graded. The images of tomatoes are captured using the camera and given as input to the system. Through training using a ripe tomato database, the chroma value of a perfect ripe tomato is determined. This value determined is used as a threshold for the tomato grading system. The captured image is converted to determine its chroma component of the captured tomato image. Output image pixels are made white while rest is black. the count of white pixels determines the maturity level of tomato.

Mehra, T., Kumar, V., & Gupta, P. [9], tells us about how a diseased or rotten tomato can be identified using K means clustering algorithm and image segmentation. A “RGB” image is converted to “LAB” image so as to distinguish between background and the green tomatoes. The average color is determined for each sample in the “AB” area.

ShamimIbneShahid, Md. Shahjahan [10], tells about an approach for image classification by convolutional neural network. To classify images of simpler visual objects taken into consideration only the colour component and size. Convolutional neural network takes into consideration many features at each layer during training and provides us high accurate image classification.

Ruchita R. Mhaski, P.B. Chopade, M.P. Dale [11], have proposed a method for determining the ripeness of tomatoes and this method is implemented using Raspberry Pi. The proposed method classifies the tomato into 3 classes using a color detection algorithm. The original RGB image is converted into HSV image. The red, yellow and green mask area is taken into consideration and each colour pixels are counted. The higher count of the pixels will determine the class of the tomato fruit.

Nikolas Lamb, MooiChooChuah [12], have proposed a fast, precise, highly efficient and affordable system using Neural Network for Detection of Strawberry fruit. This system is used to detect strawberries for mass harvesting. A live video is given as input, individual frames will be augmented with depth information to provide location of each strawberry. Predicted boundary boxes will be used to generate a path for the robot arm. This system will enable robots to replace hand picking, thereby improving agricultural efficiency and reducing crop damage.

Diana Carolina, C. P., &Deivis David, N. T. [13], have proposed a system using image processing to determine the maturity level of oranges. Through image processing can identify fruit characteristics in order to optimize selection processes and reduce the time for the classification of fruit. The process starts by capturing digital image and preprocessing the image into binary and grayscale, followed by erosion and dilation to improve the accuracy. The input image RGB features are extracted for classification by ripeness. By using the histogram the amount color is obtained according to the RGB space. The classification takes place according to the amount of colour or histogram.

III. ANALYSIS

The following table is a summary of various research papers on fruit maturity classification.

TABLE 1
ANALYSIS TABLE

Sr. No.	Paper Name	Summary	Advantages	Technique Used
01.	Assessment of Fruit Maturity using Digital Image Processing [1]	Analysis of color is an important consideration when determining the efficiency of fruit.	Real time dataset was used to train the neural network and more are used for testing.	Image processing using MATLAB
02.	ImageNet Classification with Deep Convolutional Neural Networks [2]	As deep learning is represented as a hierarchy of features that is pixel, edges, object, group of objects.	The paper shows that deep convolutional neural networks has been most successful algorithm for image recognition in the field compared to deep boltzmann machines, convolutional deep belief networks	Deep Convolutional Neural Networks

03.	Data Classification with Deep Learning using Tensorflow[3]	In the dataset there are 60,000 figures for training and 10,000 figures for the test. Each picture consists of 28x28 pixels. It has been observed that the best accuracy is achieved when the ReLu activation is used.	With the use of ReLu activation function for data classification, 98.43% classification accuracy is obtained on the test data.	Deep Learning using TensorFlow
04.	Estimation of volume and maturity of sweet lime fruit using image processing algorithm [4]	The RG ratio threshold for ripe fruit and unripe lime is fixed. Hence, can be categorized by maturity level. The fruit surface color has an affinitive relationship with the internal quality and reflects its maturity.[5].	Maturity is determined with the RGB color coding based on RG ratio.	Image Processing algorithm
05.	Predicting Fruit Maturity Stage Dynamically Based on Fuzzy Recognition and Color Feature.[6]	Tomato is the most investigated member of fleshy fruit regarding fruit development and ripening.	It is a non destructive method for determining the maturity level of tomato.	Signal Image Acquisition, Red Area and Hue Abstraction.
06.	A Cost Effective Tomato Maturity Grading System using Image Processing for Farmers.[7]	The paper proposes an inexpensive setup utilized for performing the tomato grading process.	The proposed algorithm is less complicated and more processor friendly. Hence accurate and faster classification.	Segmentation along with a simple algorithm to count the total number of white pixels, which determined the maturity level of tomato.
07.	Age factor Identification of Tomato Using Labview via Image Processing.[8]	Tomatoes are one of the most cultivated vegetables worldwide and are extensively grown as secondary crops especially in rice and corn based farming systems.	It is non-invasive which can lessen the damage to the tomato when inspecting for its ripeness or maturity.	Image Processing, RGB to HSV color that is Hue Saturation formatting.
08.	Maturity and Disease Detection in Tomato using Computer Vision.[9]	As fruits are perishable and their intake is in fresh stage, of many existing fruit disorders, immaturity and ripening are common ones.	Using neural networks, it is easy to work on the database having more information about large varieties of tomato.	Image acquisition, Pre-processing Detection and Segmentation (Thresholding), K-Means Clustering Algorithm
09.	A New Approach to Image Classification by Convolutional Neural Network.[10]	Comparing various methods for image classification by considering color components as the basic feature.	The Convolutional Neural Network predicted the image classification with accuracy of 94%.	Convolutional Neural Network

10.	Determination of Ripeness and Grading of Tomato using Image Analysis on Raspberry Pi.[11]	Color detecting algorithms are used for ripeness determination. This algorithm is implemented in Raspberry Pi to make it independent.	Detects the defects in tomato and classify them in defective class. The result analysis is able to accurately determine the ripeness of tomatoes.	Convert RGB to HSV image of tomato. Creating a red mask to determine the redness of tomato. Cluster to category using K-Means clustering.
11.	A Strawberry Detection Using Convolutional Neural Network.[12]	As agricultural automation becomes more feasible, due in part to lighter and more robust computer vision algorithms, produced detection has emerged as an essential part of the production.	The system is fast, precise and affordable for high efficiency, increases speed and precision.	Convolutional Neural Network, Image Input Compression, Color Masking, Image Tiling, Network Compression.
12.	Classification of Oranges by Maturity, Using Image Processing Techniques.[13]	The Computer vision systems for quality evaluation of food had great acceptance in the food industry, increased demand for objectivity, consistency and efficiency.	Through image processing can identify fruit characteristics in order to optimize selection processes and reduce the time for the classification of fruit.	Color uniform background using CCD (Charge Coupled Device), Image Processing, Image Segmentation and HSV color formats.

IV. CONCLUSION

In this paper a detailed study of several maturity determination approaches is done. The study consists of a few papers which discuss the techniques for strawberry fruit ripeness detection, along with its accuracy. While some explain the techniques which have been used to determine the fruit ripeness, apart from strawberry. This will help one to decide which approach to choose while determining the maturity level of Strawberry fruit. With recent developments in Neural networks for Fruit Ripeness Detection, one can create a model with faster speed and better accuracy. This can be helpful in having a real time fruit maturity detection system with better classification quality. An automatic vision based maturity detection model will help to reduce the numbers of laborers required during peak season and discrete opinion produced.

ACKNOWLEDGEMENTS

We would like to express a deep sense of gratitude towards our guide Prof. JanhaviSangoi, Computer Engineering Department for her constant encouragement and valuable suggestions. The work that we have been able to present is possible because of her timely guidance.

REFERENCES

- [1] KrantiRaut, Prof. VibhaBora, "Assessment of Fruit Maturity using Digital Image Processing", IJSTE ISSN : 2349-784X, Volume 3, Issue 01, July 2016.
- [2] A. Krizhevsky, I. Sutskever, G. E. Hinton, "ImageNet classification with deep convolutional neural networks", Proc. Int. Conf. Neural Inf. Process. Syst., vol. 60, pp. 1097-1105, 2012.
- [3] FatihErtam, GalipAydÖn, "Data Classification with Deep Learning using Tensorflow", IEEE: International Conference on Computer Science and Engineering (UBMK), 2017
- [4] Gokul, P. R., Raj, S., &Suriyamoorthi, P. (2015). Estimation of volume and maturity of sweet lime fruit using image processing algorithm. 2015 International Conference on Communications and Signal Processing (ICCSP).doi:10.1109/iccsp.2015.7322703

-
- [5] Xu Liming *, Chen Liming, Wang Haifeng, "Strawberry Maturity Distinguish Based on Relationship of Extracted Colour Feature Value and the Physiologic and Biochemical Indices", 2015 International Conference on Communications and Signal Processing (ICCSP),DOI: 10.1109/ICCSP.2015.7322703
- [6] Xiao, Q., Niu, W., & Zhang, H. (2015). Predicting fruit maturity stage dynamically based on fuzzy recognition and color feature. 2015 6th IEEE International Conference on Software Engineering and Service Science (ICSESS).doi:10.1109/icse.2015.7339210
- [7] Aviso, M. J. A., Cabao-an, A. M. S., Niverba, N. A. P., &Anacan, R. M. (2018). Age Factor Identification of Tomato Using Labview via Image Processing. TENCON 2018 - 2018 IEEE Region 10 Conference. doi:10.1109/tencon.2018.8650189
- [8] Rupanagudi, S. R., Ranjani, B. S., Nagaraj, P., &Bhat, V. G. (2014). A cost effective tomato maturity grading system using image processing for farmers. 2014 International Conference on Contemporary Computing and Informatics (IC3I).doi:10.1109/ic3i.2014.7019591
- [9] Mehra, T., Kumar, V., & Gupta, P. (2016). Maturity and disease detection in tomato using computer vision. 2016 Fourth International Conference on Parallel, Distributed and Grid Computing (PDGC). doi:10.1109/pdgc.2016.7913228
- [10] Shahid, S. I., &Shahjahan, M. (2017). A new approach to image classification by convolutional neural network. 2017 3rd International Conference on Electrical Information and Communication Technology (EICT). doi:10.1109/eict.2017.8275240
- [11] Mhaski, R. R., Chopade, P. B., & Dale, M. P. (2015). Determination of ripeness and grading of tomato using image analysis on Raspberry Pi. 2015 Communication, Control and Intelligent Systems (CCIS). doi:10.1109/ccintels.2015.7437911
- [12] Lamb, N., &Chuah, M. C. (2018). A Strawberry Detection System Using Convolutional Neural Networks. 2018 IEEE International Conference on Big Data (Big Data).doi:10.1109/bigdata.2018.8622466
- [13] Diana Carolina, C. P., &Deivis David, N. T. (2014). Classification of oranges by maturity, using image processing techniques. 2014 III International Congress of Engineering Mechatronics and Automation (CIIMA).doi:10.1109/ciima.2014.698.