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Identification of mature Nutmeg using Colour Space segmentation Algorithm

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Abstract

Automation in Agriculture is essential to achieve a better quality harvest and alleviating the dependency on human workers. As the southern part of India is rich in spices cultivation, the work emphases on one of the spice which has got more medicinal value and commercial viability. The spice considered in this is nutmeg which is mostly cultivated in the mountain ranges of Kerala and Kanyakumari District. The identification of mature nutmeg in a large group is a bit time consuming task. The current fruit-picking methods takes a long time in fixing the clamp on the right fruit from the cluster of fruits, these leads to the cervical spondylitis problem. Recent developments in image processing and the extensive usage of autonomous platforms have provided the opportunity for fast and automatic harvesting machines. This paper proposes an image segmentation algorithm to identify the mature nutmeg. The datasets used are KAU Kochukudy, IISR Keralashree, Punnathanam and local clone. The matured fruit is identified by it's boundaries using the boundary edge detection algorithm. The color detection method and colour space method were considered. Boundary Edge Detection algorithm is focused on identifying the edges or boundaries present in an image. Color Detection Method relies on identifying objects based on their color characteristics.Colour Space method involves converting the image from RGB color space (Red, Green, Blue) to a different color space, which may be more effective for certain types of analysis. Colour space methods outperforms image segmentation algorithm in terms of identification of matured nutmeg images with 96% accuracy. The average elapsed time was 1.150 secs. Also, the processing time to identify the right matured fruit requires much lesser time than other methods.

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Introduction

Nutmeg, Myristica fragrans is a perennial aromatic spice that belongs to the Myristicacea family and is native to Indonesia. Globally, India is the second-largest producer[8] of nutmeg yielding around 16,000 metric tons annually. The states of Kerala, Maharashtra, Tamil Nadu, and Karnataka are the main nutmeg cultivating regions in India.[10]

Nutmeg trees can reach a height up to 25 feet, with wide branches. The Nutmeg tree is known for their unique sweet and slightly spicy flavor, and produces two separate spices called nutmeg and mace. The Nutmeg fruits are highly valued for their medicinal values, especially for the issues related with cancer, kidney diseases, Nausea, and intestinal problems.[19] The Nutmeg varieties include KAU- Kochukudy, IISR Keralasree, Kadukanmakal, Kallivayal, Kinattukara, Mundathanam, Konkan Sreemanti, Pullans, Konkan Suganda, Konkan Swad, Naveswari, KAU-Punnathanam, Edavarembil Gold, and Local Clones.IISR Viswashree developed by Indian Institute of Spices Research (IISR) is the most widely used variety of nutmeg. It yields over 1000 fruits from the eighth year of planting whereas a typical nutmeg tree takes around 20 years to reach its peak harvesting period.

Harvesting the matured nutmeg using the traditional process is a crucial process. Identifying and plucking the matured nutmeg is difficult and more skill is required. Harvesting immature nutmegs without proper knowledge leads to the economic fall, less harvesting rate and increased fatigue for labour. Traditionally, lack of labours is the main challenge faced by the farmers. Existing machine harvesting systems cannot completely replace manual fruit plucking skills. Researchers are trying to develop effective fruit harvesting methods in order to attain the efficiency. To tackle the issues in agricultural sector, numerous automation techniques have been developed using image processing techniques.[22] Harvesting using image processing techniques make it challenging because of the environmental factors. The nutmeg fruit is either plucked from the tree or allowed to drop on the ground and is handpicked. The aim is to reduce human effort by promoting automation concepts in agriculture.[18] Automated identification of fruit with image processing is a keystone in agriculture. The work presented in this paper automatically identifies the mature fruits using image processing techniques. Image segmentation technique is considered, and the methods are explained briefly in the below sections. Image segmentation algorithms like Boundary Edge Detection algorithm, Color Detection Method and Colour Space method were considered.

The design and development of mango fruit harvesting with Shear type method[17] was introduced.50% damage is reduced. A machine vision system was implemented to identify the defects of an apple with accuracy 90%.[16] Previous research mentioned different fruit harvesting sensors using image processing techniques and soft computation methods.[2] Support vector machine6, artificial neural network algorithm[4] are the other implementation techniques used for fruit harvesting. The complexity of the system is increased with these methods and more training samples are required to display the exact output. Hyper spectral cameras,[11] Thermal imaging cameras,[23] color cameras, are used for data collection .Generally, the colour of the fruit, the texture and the geometry are the important features which helps to distinguish fruit from the leaves, branches, and other background objects in the farm. Also, clustering, lighting conditions,[14] occlusion[1] are the main challenges faced with the detection of fruits. By applying Shape color based method[15] 85% of accuracy is achieved. Later on, another method was developed in which classification and recognition of the fruits is done by adding colour to the fruits.

Citrus counting algorithm[13] was developed by converting RGB to HSV colour space. The correlation coefficient, 0.93 was achieved by this method. But, training phase and the testing phase is very difficult. Image processing techniques 9 for weight prediction and the disease in the fruit was developed for mango[17] grapes and apple. Back propagation method was used and 90% accuracy is achieved.

The objective is to identify matured nutmeg fruits using different methods: boundary edge detection, color detection, and color space conversion. The color space method performs better than the other two image segmentation algorithm, achieving 96% accuracy in identifying matured nutmeg images. Mature nutmegs tend to have specific color characteristics that distinguish them from immature

ones. Identifying these differences, making it faster and more efficient compared to manual sorting using a color space segmentation algorithm

Additionally, the average elapsed time for this method is 1.150 seconds. This method also requires less processing time compared to other methods in identifying the right matured fruit.

Methodology

Initially the survey is done on various natures of the farms and traditional challenges are identified. There are many different clones available in the nutmeg species, more data on these clones and their varieties has been collected in order to train the image processing system. An image processing algorithm is developed for sensing the right ruptured nutmeg fruits. The ruptured fruit is identified by the selection of the boundaries in the mature fruit. A database is made using images from various nutmeg clones and types. This database trains the algorithm to improve nutmeg maturity detection, which ultimately boosts profits for farmers.

Fig. 1: Matured Kochukudy Nutmeg

Fig. 2 : Matured fruit as a bunch

Fig. 3: Immature Keralashree Fruit

Fig. 4: Bunch of Punnathanam clone

Fig. 5: Images of Local Clones

The Collected data sets were trained with image processing algorithms.Three image processing algorithms were incorporated, and the results were carefully analyzed and noted for further modifications. The ruptured fruit is identified by the selection of the boundaries in the mature fruit. Real time data sets are created for few clones and are given below. The figure 1-5 displays different nutmeg varieties, including Kochukudy, Keralashree, Punnathanam, and their corresponding mature and immature fruit images.

When the collected data were comprehended, it was observed that most of the fruits were on a solo pattern but there were rare cases where the fruits bear as clusters. Hence, a new challenge evolved to isolate the matured fruit from the cluster and the image processing methodology has to be tuned based on the requirements.

Boundary Edge Detection algorithm, Color Detection Method and Colour Space method are the three image segmentation algorithm used to point out the mature fruit. In Boundary Edge Detection algorithm,[24] it was observed that while using this algorithm, immature fruits were not identified in an efficient manner. Therefore Color Detection Method is used. It was observed while employing color detection method, it was noted that the processing time varies for different clones of the nutmeg. Therfore we go for colour space method.

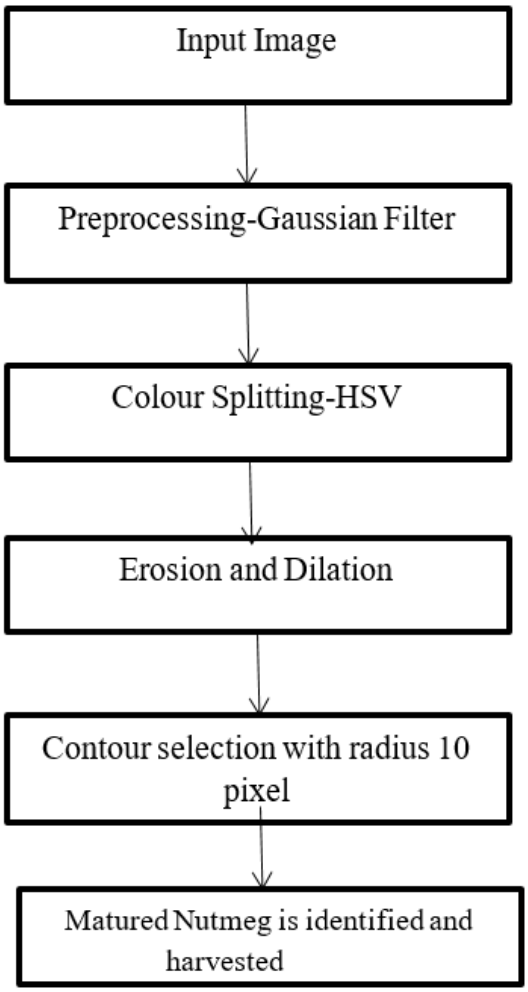

Fig. 6 : Identification of Mature Nutmeg using segmentation Algorithms

Fig 6 shows the steps involved in the Identification of Mature Nutmeg using segmentation algorithms. The input image is pre-processed with a Guassian filter, which helps to reduce noise and enhance edges. Then the image is converted from RGB color space into HSV color space. To improve the segmentation, we use erosion to remove small noise and dilation to close gaps in the segmented regions. A specified radius of 10 pixels is used to define circular regions around identified contours. Finally, matured nutmeg is identified and harvested.

Colour Space Method

In Colour Space method, the images of the different clones of nutmeg were captured using the camera from different regions. The obtained RGB images were processed using the image processing system. The obtained nutmeg images were analyzed using different algorithms and the following results were obtained. The species used for the identification of mature nutmeg are KAU Kochukudy, IISR Keralashree, KAU Punnathanam, and local clone.

In this method the input colour image of the nutmeg is converted to binary image and from the binary image the Region of Interest (RoI) is extracted by using a binary mask.[7] In the Binary mask image, pixels that belong to the ROI are set to 1 and pixels outside the ROI are set to 0. The extracted Mature Nutmeg using Colour space method is displayed below.

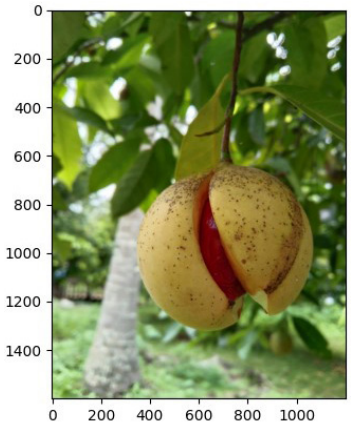

Fig. 7 : input Image

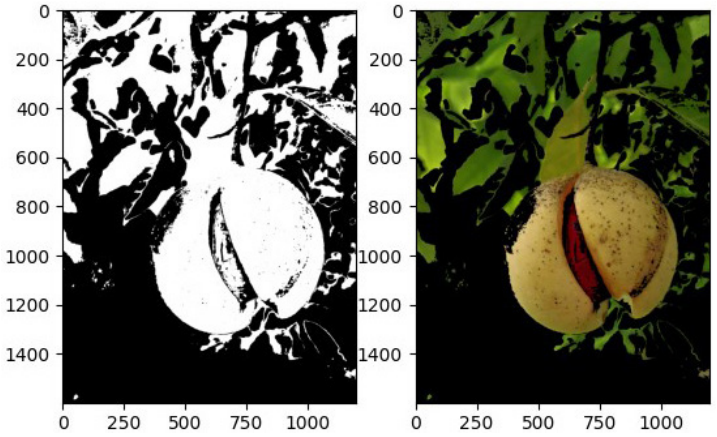

Fig. 8 : Binary images

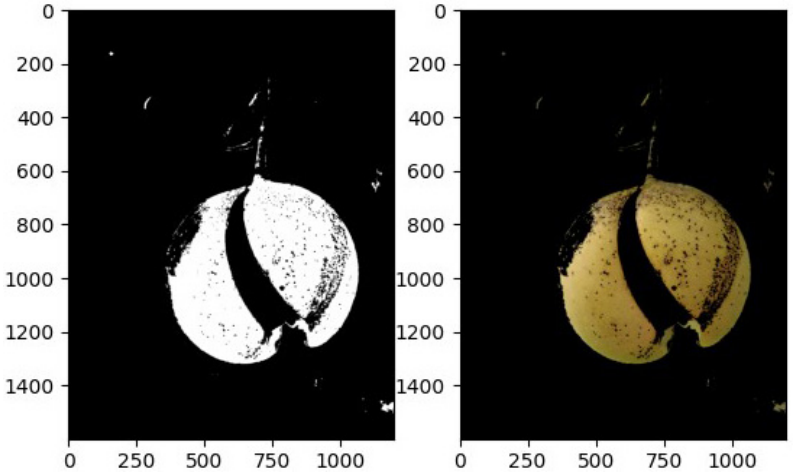

Fig. 9: Extracted Mature Nutmeg using Colour space method

With image segmentation algorithm, the mature fruit is identified among the immature fruit. Some varieties of nutmeg images with the available data base. Fig 10-14 shows the input image with their respective binary image and the extracted matured image of the species KAU Kouchukudy and IISR KeralaShree.

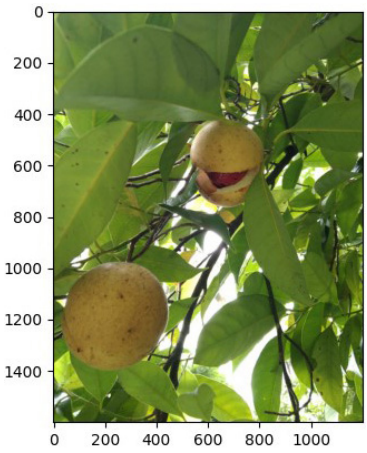

Fig. 10: Input Image

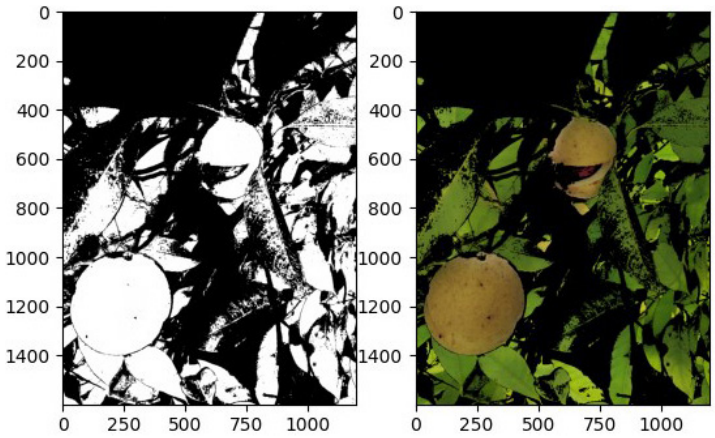

Fig. 11: Binary image

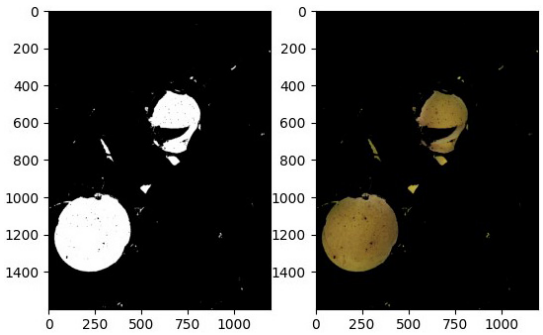

Fig. 12: Extracted Mature Nutmeg

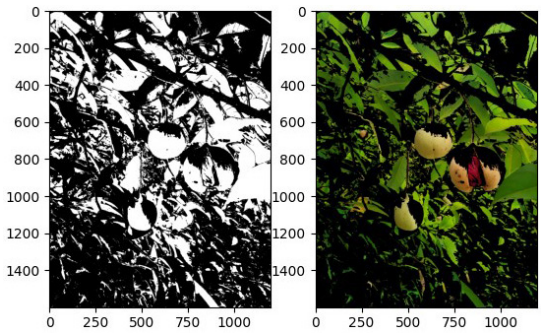

Fig. 13: Binary image

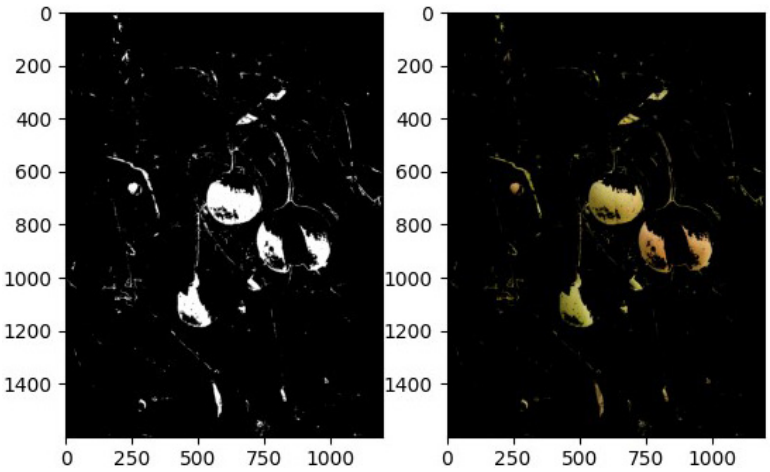

Fig. 14: Extracted Mature Nutmeg

Analysis

For the result analysis, the Boundary Edge detection algorithm and colour detection method is compared.

Boundary Edge Detection Algorithm

In this method, the mature nutmeg image was captured; the colour image was converted into binary image and then given as an input to the system. The Boundary Edge Detection algorithm was done on the binary image to detect the mature nutmeg fruit with the help of its split boundaries.[22] The mature and immature fruits were identified by using this algorithm. However, it may be somewhat time-consuming when identifying mature nutmeg in a large group. Gaussian smoothed step edge (an error function) is used as the simplest extension of the ideal step edge model for modelling the effects of edge blur in practical applications

Thus, a one-dimensional image 'f' that has exactly one edge placed at x=0 may be modelled as

$$F(x) = \frac{Ir-Il}{2}(\text{erf}(\frac{x}{\sqrt{2\sigma}}) + 1) + Lr \quad ...(1)$$

At the left side of the edge, the intensity is

$$\text{Il} = \lim_{n\to\infty} F(x) \quad ...(2)$$

And right of the edge the intensity i

$$\text{Ir} = \lim_{n\to\infty} F(x) \quad ...(3)$$

The scale parameter σ is called the blur scale of the edge. Ideally this scale parameter should be adjusted based on the quality of image to avoid destroying true edges of the image. The below figure shows the binary image of matured nutmeg, identification of nutmeg in cluster and immature nutmeg images using boundary detection method. Figures 15 to 17 displays the simplified image of mature nutmeg, the process of identifying nutmeg in clusters, and the identification of immature nutmeg using boundary detection.

Fig. 15: Binary image of matured Nutmeg

Fig. 16: Identification of Nutmeg in cluster

Fig. 17: Identification of Immature nutmeg using Boundary detection method

Colour Detection Method

The color detection method is more effective[19] in identifying clustered fruits compared to the earlier boundary detection method. In this colour detection method the raw image is given to the image processing system. The identification of the mature and immature fruit is indicated using the shape of the fruit. The extracted Mature Nutmeg using Colour Detection method is shown below. This method has been analysed on the different clones and it is observed that the processing time differs from clone to clone. Colour quantization is usually done using the "straight-line distance" or "nearest colour" algorithm, which simply takes each colour in the original image and finds the closest palette entry, where distance is determined by the distance between the two corresponding points in three-dimensional space. In other words, if the colours are $(r_1,b_1,g_1)^2$ and $(r_2,b_2,g_2)^2$

$$\text{Min} = \sqrt{(r1, b1, g1)2 - (r2, b2, g2)2} \quad \ldots(4)$$

Fig 18 shows the input image of the nutmeg. Fig 19 shows the binary image of the nutmeg. The mature nutmeg, obtained through the color detection method, is presented in Figure 20.

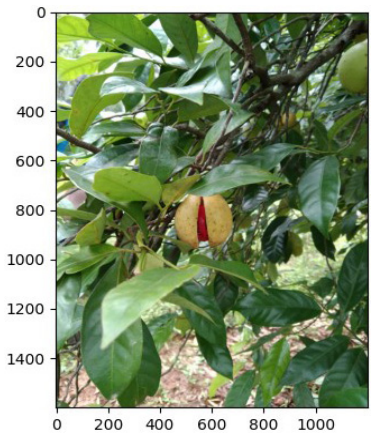

Fig. 18: Input Image

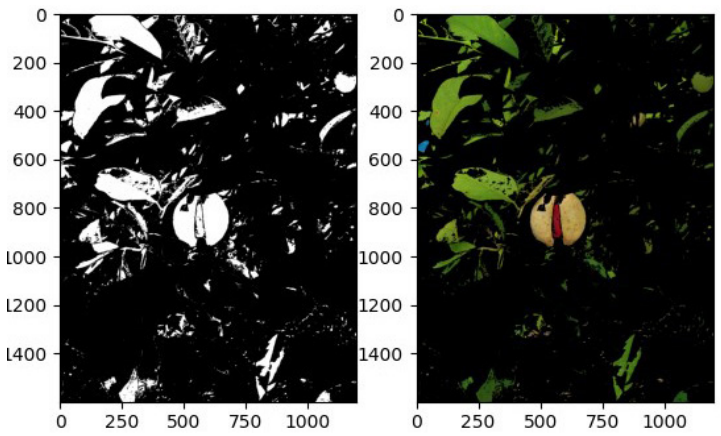

Fig. 19: Binary image

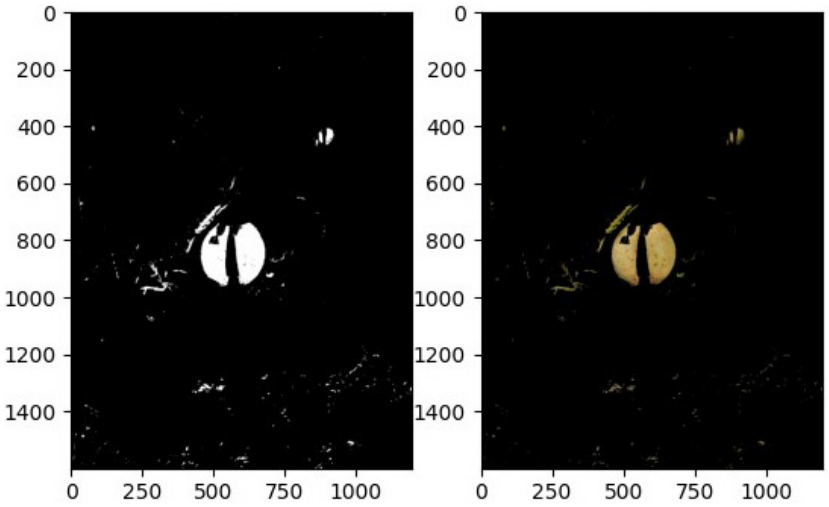

Fig. 20: Extracted Mature Nutmeg using Colour Detection method

Results and Discussions

Three image processing algorithms were developed and compared to find the mature fruits in a Nutmeg tree. The results displayed below shows the different varieties of nutmeg collected from the different farms and simulation output for the extracted matured

images. By using Boundary Edge Detection and Color Detection Method algorithm, it was noted that, immature fruits were not identified in an efficient manner. Therefore Color space method is used. By using this method, the mature fruits can be identified. The processing time is less and efficiency is high when compared to the previous method. The Nutmeg varieties collected are KAU Kochukudy, IISR Keralashree, KAU Punnathanam and local clone.Fig 21 shows the simulation output for KAU Kochukudy. Processing time for KAU Kochukudy is 1.35 sec. Fig 22 shows the simulation output for IISR Keralashree. Processing time for IISR Keralashree is 1.17 sec. Fig 23 shows the simulation output for KAU Punnathanam. The processing time for KAU Punnathanam is 1.161 sec.

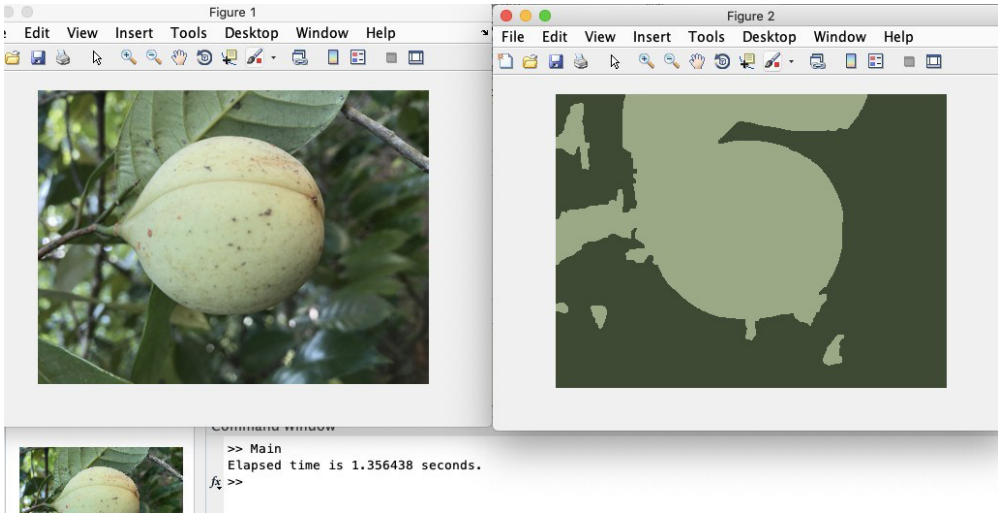

Fig. 21: Simulation output for KAU Kochukudy

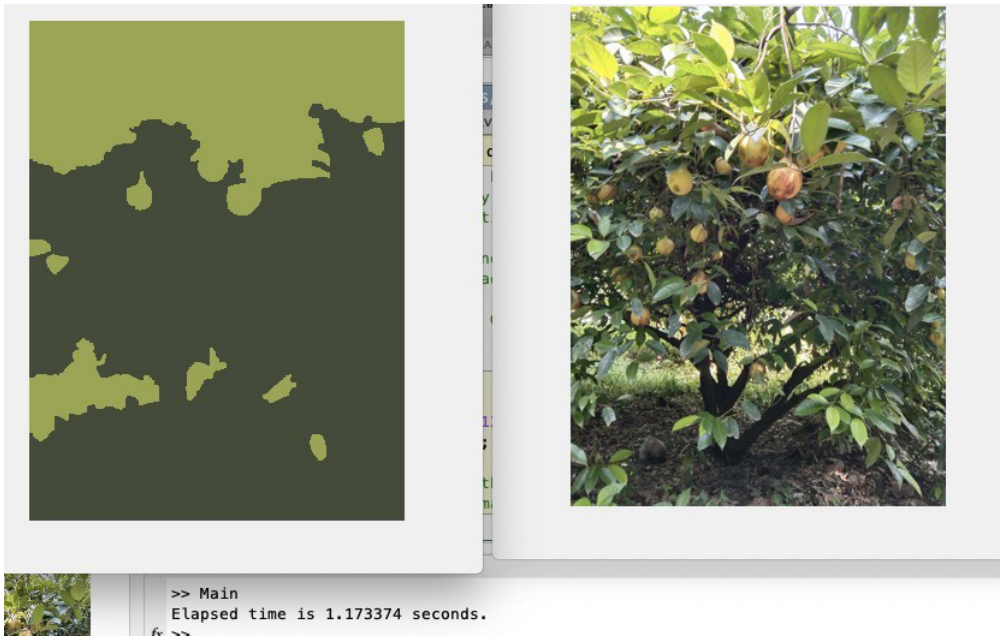

Fig. 22 : Simulation output for IISR Keralashree

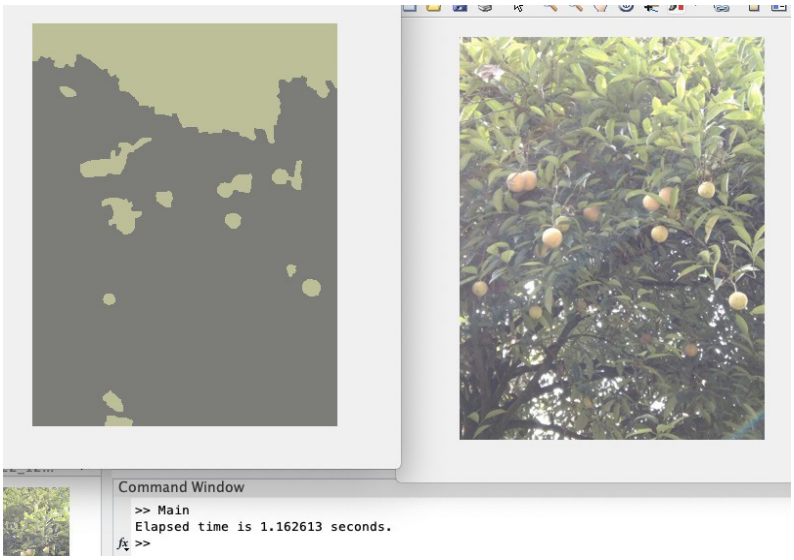

Fig. 23:Simulation output for KAU Punnathanam

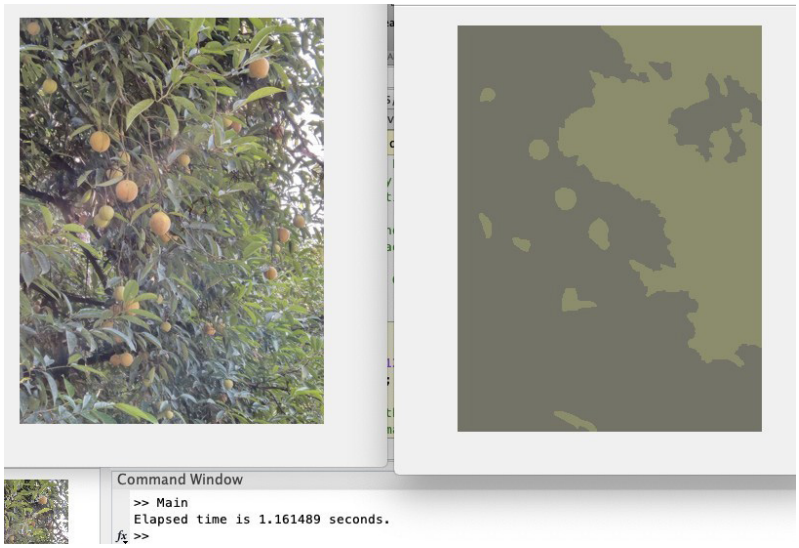

Fig. 24:Simulation output for local clone

Fig 24 shows the simulation output for Local Clones. The processing time for local clone is 1.162 sec

By using Colour Space method, the processing time to identify the mature nutmeg is reduced. The table below shows the comparison for the processing time of different varieties of Nutmeg for the above mentioned three image segmentation algorithms.

The table above displays the processing times for various Nutmeg varieties, comparing both the current algorithm and the new approach. The figure illustrates that the proposed method significantly reduces processing time.

Table 1: Comparison of Processing times of different varieties of Nutmeg

Clones	Edge Detection Method (sec)	Colour Detection Method (sec)	Coloure Space Method (sec)
KAU Kouchukudy	1.56	1.35	1.2
IISR KeralaShree	1.38	1.17	1.05
Punnathanam	1.80	1.161	1.042
Kodumamackal	1.32	1.173	1.05
Local Clone	1.164	1.162	1.044

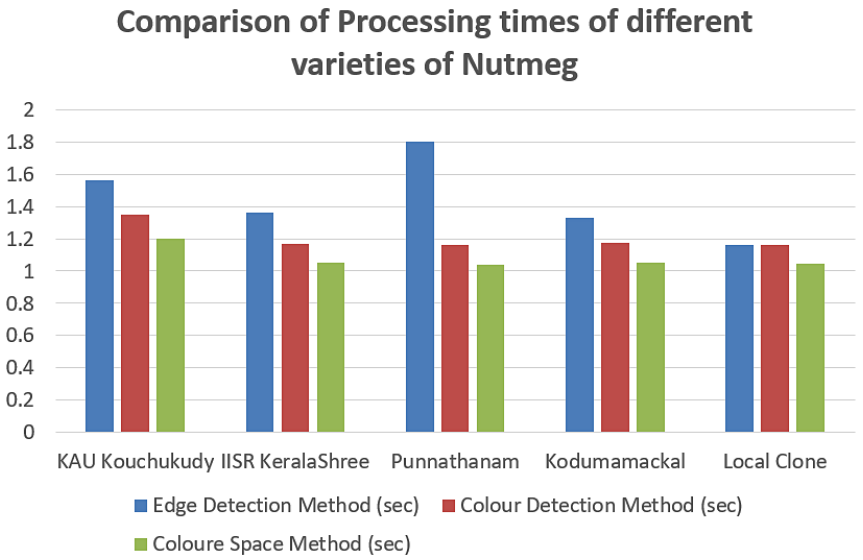

Fig. 25: An illustration of the processing times for various nutmeg species in a bar chart

Conclusion

We have come up with the solution for detection of matured nutmeg spice. Image segmentation algorithm was developed to harvest nutmeg spices. Three new algorithms were developed. Boundary Detection, Colour Detection and Colour Space methods are used for computation. Fruit identification using image processing is a difficult task. We attain better results when compared to the previous work. The Simulation results of Boundary detection, Colour detection and colour space methods are compared. Colour space method outperforms the other two methods in terms of identification of matured nutmeg images with 96% accuracy. The proposed methods can easily identity the matured nutmeg fruits based on color and texture features. As the nutmeg is identified using the Colour space method, the processing time to identify the right matured fruit requires much lesser time than other methods. The average elapsed time was 1.150 secs was achieved. Fast recognition of the mature fruits is the main advantages of this system. For Future work, it is planned to develop an automatic handy and portable nutmeg harvesting machine without damaging the mace for nutmeg harvesting.

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Conflict of Interest
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