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# Fruit Detection and Sorting based on Machine Learning

**[1]Gayathri A [2]Aparna Menon [3]Amitha Jiju [4]Divya V Chandran**
[1,2,3]Student [4]Assistant Professor
[1,2,3,4]Department of Electronics and Communication Engineering
[1,2,3,4]Adi Shankara Institute of Engineering and Technology, Ernakulam, India

## Abstract

Agriculture is main occupation of Indian people. In agriculture field, the difficulty of detection and counting the number of on trees fruits plays a crucial role in fruit orchids. Manually counting of fruits has been carried out but it takes lot of time and requires more labor. The purpose of the system is to minimize the number of human computer interactions, speed up the identification process and improve the usability of the graphical user interface compared to existing manual systems. The hardware of the system is constituted by a Raspberry Pi, camera. This system includes preprocessing of images, extraction of features and classification of fruit using machine-learning algorithms. This paper presents computer vision and machine learning techniques for on tree fruit detection, counting and sorting.
**Keyword- Graphical User Interface**

## I. INTRODUCTION

Now a day's human life is very busy. Everyone wants to do their work within a very few time, accurately and in low cost. So this type of desire can only fulfil by the advance technology. Fruit counting is time taking and need large manpower with more cost. The purpose of implementing computer vision to the system is to narrow the selection of possible objects and thus reduce the strain on the user. So to avoid these types of problem it is necessary to have automatic fruit detection and counting algorithm for better performance. To achieve good object detection, classification and recognition, different machine learning algorithms and object's feature extraction algorithms are used. We need to select the (best) algorithm with the highest classification and prediction accuracy. While training the system, proper learning rate also plays a vital role. For fruit classification and detection this project implements a portion of computer vision and object recognition with machine learning model. The fast development of image processing, computer vision and object recognition, development in computer technology provides the possibility of fruit classification through computer vision. In latest years, fruit identification using computer vision is being applied in agriculture sector, education sector.

## II. LITERATURE SURVEY

Identification of fruits and vegetables are implemented in different areas. The most common areas are identification in there tail business, and in areas where the purpose is to ease the harvest in the perspective of agriculture. In the retail business, the identification is mostly done manually by a cashier, or via the self-service systems in a store.

Fruit counting is time taking and need large manpower with more cost. So to avoid these types of problem it is necessary to have automatic fruit detection and counting algorithm for better performance. Grading of fruits after harvesting is an essential step in post-harvest management. Grading of fruits on basis of physical characteristics like weight, size, color, shape & freedom from diseases depending upon agro climatic conditions. But for such grading large expertise man power is required. To overcome this it is necessary to have an automatic fruit grading system, to class different grade.

The proposed system for identification and apple fruit counting fully meets the intended objectives. This system can be used to automate the fruit counting process, which can be used further to save the money spent on manual counting as well as the loss due to erroneous estimations.[1]

The sorting of mango can be done based on its maturity level, CCD camera is used to capture video sequence, pseudo median filter is used to remove noise, for edge detection and boundary tracking image is converted to binary image . It shows an overall accuracy of 90% [2].

M. Bulanon et al. [3] presents algorithm to automatic recognize the fruits for a machine based vision system that teaches a robotic harvesting. Fuji apple fruit images which was increased by using the red color threshold. Results explain that apple fruit had the greatest red color threshold within the object in the image. The histogram was obtained by the increased image had a bimodal distribution for the object as a fruit portion and the background such as leaves and branches portion. Maximum grey level threshold of the red color difference between the fruit, leaves and branches was determined by the maximum threshold value.

A working model of a date fruit grading and sorting system including both the hardware and the software is built [4]. The hardware includes the conveyer, camera control and helm control systems. The software system analyzes the fruit image and classifies them. The maximum accuracy of the system is 80% which is attained by model 2 in classifying the grade 2 fruit. They observed problems in detecting the flabbiness from the color. An impact sensor might improve flabbiness detection.

## III. COMPUTER VISION

With the advancement of Artificial Intelligence, Computer vision came into the picture in late 1960s. Its whole purpose was to increase the intellect of the artificial mechanism available by installing the cameras into them and describe whatever they saw just like humans' visual system. Thus, Computer vision should be able to detect actual daily-life 3D objects through 2D pictures. Every picture tells us a story, something present now or what has been going on at a particular time.

OpenCV:OpenCV is Open Computer Vision Library. It was initially launched in 1999 by Intel. With more updates, it has been modified since then to aim for the real-time computer vision. This library has been written under programming languages like C and C+. It can be easily run on operating systems Windows and Linux. This library can be easily interface with programming languages like Python, MATLAB, Ruby and others as well. Along with Numpy and Python image processing (shape & color detection) can be performed at ease. Automatic computer vision method is reliable method for sort and grade of fruits. This paper presents the improvement of computer vision in the horticultural sector. Cheap, higher speed and correct counting and sorting would be realized using computer vision technique.

## IV. METHODOLOGY

Several fruit recognition techniques are developed based on different attributes. Here, using color features and shape features analysis methods are used to identify and distinguish fruits images. A new fruit recognition and sorting system has been proposed, which combines features analysis methods: color-based and shape-based. The proposed method classifies and recognizes fruit images and sort them based on obtained feature values by using nearest neighbours classification. Consequently, our system shows the fruit name and the count of the fruits on GUI.

### *A. Image Acquisition*

The first stage of any vision system is the image acquisition stage.After the image has been obtained, various methods of processing can be applied to the image to perform the many different vision tasks required today.However, if the image has not been acquired satisfactorily then the intended tasks may not be achievable, even with the aid of some form of image enhancement.

### *B. Background subtraction*

Background subtraction is a major preprocessing step in many vision-based applications. For example, consider the case of a visitor counter where a static camera takes the number of visitors entering or leaving the room, or a traffic camera extracting information about the vehicles etc. In all these cases, first you need to extract the person or vehicles alone. Technically, you need to extract the moving foreground from static background.

If you have an image of background alone, like an image of the room without visitors, image of the road without vehicles etc, it is an easy job. Just subtract the new image from the background. You get the foreground objects alone. But in most of the cases, you may not have such an image, so we need to extract the background from whatever images we have. It becomes more complicated when there are shadows of the vehicles. Since shadows also move, simple subtraction will mark that also as foreground.

### *C. Conversion of RGB to HSV*

Color vision can be processed using RGB color space or HSV color space. RGB color space describes colors in terms of the amount of red, green, and blue present. HSV color space describes colors in terms of the Hue, Saturation, and Value. In situations where color description plays an integral role, the HSV color model is often preferred over the RGB model. The HSV model describes colors similarly to how the human eye tends to perceive color. RGB defines color in terms of a combination of primary colors, whereas, HSV describes color using more familiar comparisons such as color, vibrancy and brightness. The basketball robot uses HSV color space to process color vision.

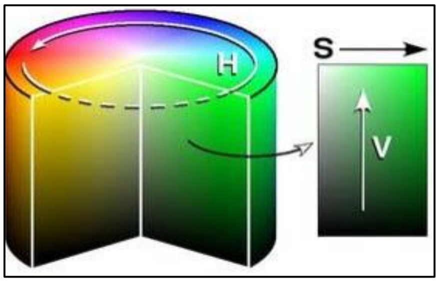


Fig. 1: Illustrates how hue, saturation, and value are defined

- Hue represents the color type. It can be described in terms of an angle on the above circle. Although a circle contains 360 degrees of rotation, the hue value is normalized to a range from 0 to 255, with 0 being red.
- Saturation represents the vibrancy of the color. Its value ranges from 0 to 255. The lower the saturation value, the more gray is present in the color, causing it to appear faded.
- Value represents the brightness of the color. It ranges from 0 to 255, with 0 being completely dark and 255 being fully bright.
- White has an HSV value of 0-255, 0-255, 255. Black has an HSV value of 0-255, 0-255, 0. The dominant description for black and white is the term, value. The hue and saturation level do not make a difference when value is at max or min intensity level.

### *D. Thresholding*

Image thresholding is a simple, yet effective, way of partitioning an image into a foreground and background. This image analysis technique is a type of image segmentation that isolates objects by converting grayscale images into binary images. Image thresholding is most effective in images with high levels of contrast. Common image thresholding algorithms include histogram and multi-level thresholding.

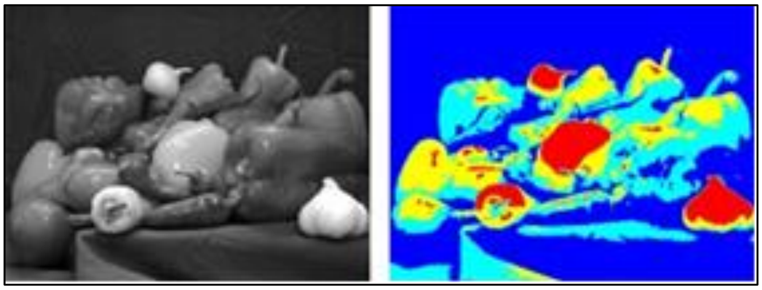

Fig. 2: Image thresholding using multi-level thresholding

Fig. 3: Image thresholding using a set level

### *E. Colour Detection*

Open CV allows us to open an image and store it in a 3 dimensional array or matrix where the x and y axis designate the location of the pixel in the image and the z axis designates the RGB colour channel. Each RGB pixel contains an 8 bit red component, an 8 bit green component, and an 8 bit blue component. When combined they give us the colour of the pixel in question. An RGB value of (255, 255, 255) means that the intensity of each colour component in this pixel is 255, which is the maximum intensity that the 8 bit value can be in decimal. The RGB value (255,255,255) designates the colour white as our eyes would see. At the other end of the RGB spectrum when all RGB components are at intensity 0 i.e (0, 0, 0) the screen would render a black pixel.

### *F. Shape Detection*

While purchasing fruit as well as for classification and grading, shape is considered very important. The objective of the shape description is characterize the shape in such a way that the values are very similar objects in the same form class or category, and quite different for objects in different categories. This is known as the uniqueness condition. Besides the uniqueness and invariance to affine transformations, namely translation, rotation, scaling, others desirable property of any shape description method is nonambiguity or completeness. Size dependent measurements of shape include compactness, elongation, convexity, roughness, etc. while size-independent measurements of shape includes region-based (statistics of pixel's spatial information) and boundary-based (Fourier transform, discrete wavelet transform, autoregressive models, etc.). Multiple appearances with color, shape and size feature are used for identification of Strawberry cultivar and its quality evaluation in where classification is increased to 68% compared to single feature. In [32], local binary pattern (LBP) or weber local descriptor (WLD) histogram with Fisher discrimination ratio (FDR) based feature selection is used for shape-size and texture based Date fruit classification and achieved 98% classification accuracy. Color histogram, texture and shape features used with PCA, fitness-scaled chaotic artificial bee colony (FSCABC) algorithm and feed forward neural network (FNN) to classify fruits in. Accuracy achieved is 89.1%. Reviews of different fruit grading systems and parameters are discussed in detail. Fourier-descriptor is used for shape feature extraction with SVM to classify mangoes and has achieved almost 100% classification results in. Shape, texture and color (HSV) feature extraction is used to classify 20 categories of fruits.

### *G. Noise Removal and Thresholding*

Digital images are prone to various types of noise. Noise is the result of errors in the image acquisition process that result in pixel values that do not reflect the true intensities of the real scene. There are several ways that noise can be introduced into an image, depending on how the image is created. If the image is acquired directly in a digital format, the mechanism for gathering the data (such as a CCD detector) can introduce noise. We can use linear filtering to remove certain types of noise. Certain filters, such as averaging or Gaussian filters, are appropriate for this purpose. For example, an averaging filter is useful for removing grain noise from a photograph. Because each pixel gets set to the average of the pixels in its neighbourhood, local variations caused by grain are reduced.

The noise removal have two steps i.e. masking the noise then remove the masked noise. The noise masking algorithm perform some kind of classification using thresholding and segmentation principally. To masking the noise, some series of processing step performed i.e. masking the area that close to the left and right border, filter the masked area with the amplitude threshold to get the noise temporary, segmented the noise and filter the noise with the segmentation size.

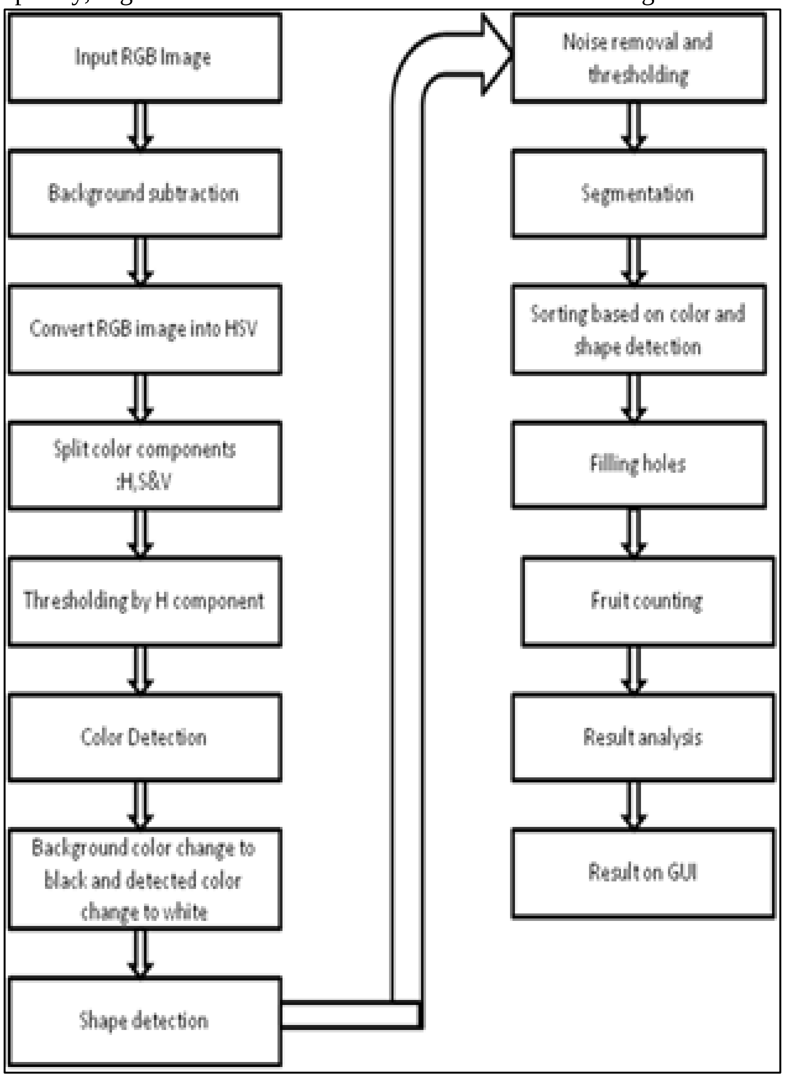


Fig. 4: Block diagram of the proposed system

### *H. Segmentation*

The process of partitioning a digital image into multiple segments is defined as image segmentation. Segmentation aims to divide an image into regions that can be more representative and easier to analyze. Such regions may correspond to individual surfaces, objects, or natural parts of objects. Typically image segmentation is the process used to locate objects and boundaries (e.g., lines or curves) in images. Furthermore, it can be defined as the process of labeling every pixel in an image, where all pixels having the same label share certain visual characteristics. Usually segmentation uses local information in the digital image to compute the best segmentation, such as color information used to create histograms or information indicating edges, boundaries, or texture information.

Color image segmentation that is based on the color feature of image pixels assumes that homogeneous colors in the image correspond to separate clusters and hence meaningful objects in the image. In other words, each cluster defines a class of pixels that share similar color properties. As the segmentation results depend on the used color space, there is no single color space that can provide acceptable results for all kinds of images. For this reason, many authors tried to determine the color space that will suit their specific color image segmentation problem. In this work, a segmentation of color images is tested with different classical color spaces RGB, XYZ, CMY, YUV and HSV to select the best color space for the considered kind of images.

### *I. Sorting based on Colour and Shape Detection*

Sorting large of fruits manually is a time consuming process. As the sorting depend upon skill of particular person, skill varies from person to person so it is not accurate process Probability of error occurrences is more in manual sorting and cost is also high. To fulfil International market demand of fruits these agro industries must work with greater accuracy, more consistently and very efficiently. So automation is necessary in post-harvest process such as sorting and grading.

Grading and sorting is done based on external and internal quality factors. The external factors are color, size, volume, shape and texture. There various methods used for color detection, size and volume calculation, shape, and for skin defect detection. But main condition is that the grading and sorting method must be non-destructive.

### *J. Fruit counting*

The final step of the proposed fruit counting technique is to detect monolithic fruit regions, which are also known as blobs or objects. After the erosion operation, we find the connected components in the binary image using 8-connectivity. Each connected component corresponds to one orange. We count the number of connected components which gives us the number of fruits in a particular tree image. This is the GUI for detection of different fruits of the images. Thus this division makes the calculation of number of different fruits easier. The various steps of the algorithm on the test image are presented in the next section.

Fig. 5: K-means segmentation step-The image on left is the input image while that on right is the output after k-means segmentation is applied

## V. RESULTS

Image is take as input from open dataset of fruit which is available online or video and images obtained by digital camera can also be taken as input. Image should be capture in the day time in the cloudy weather. Pre-processing on the images is done by using computer vision OpenCv libraries in python by importing some libraries such as numpy,scipy,scikit,matplotlib and applying K-means clustering algorithm to determine ripe and unripe fruit and accurate result has obtained within 2 second as soon as input is given. Results obtained is as shown below:

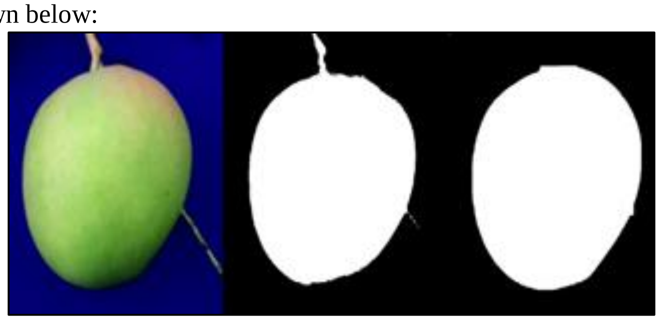

Fig. 6: Fruit detected based on colour

## VI. CONCLUSION

This paper presents the survey on, On-tree detection, counting and sorting of fruits. This system can be used to automate the fruit counting process, which can be used further to save the money spent on manual counting as well as the loss due to erroneous estimations. This area has a lot of future scope, which when implemented in future will prove to be a very effective system to be used in the agricultural field. In case of detection of on tree fruits image acquisition, image processing which includes image enhancement, image features extraction and image feature classification followed by detection colour-space segmentation, RGB colour recognition, HSI technique are used. For counting of fruits there were very few work has been done. Mainly for counting of fruits morphological operation has been used. Some of the future aspects are following which can help the researchers working in the same field of research:

- The research area is not only limited for detection, identification and counting of on-tree fruits in agricultural field but also overlapping of fruits and shape recognition can be separated by using various algorithms.

- Grading of fruits is another wide area of research, that to know the quality of fruits and according to that price can be determine for commercial purpose.
- Mobile based application can be designed by using an automate on-tree fruits detection and counting technique that will help for providing quick and accurate solution.

The on-tree counting and post-harvest grading area of research cannot be limited to above mentioned future scope. There are more other area where researcher have to explore for new innovation. In this review, as there are so many methods are proposed and implemented to detect, count and quality analysis of fruits using image processing and machine vision technique. The main objective of the paper is to describe an overview of technical concepts used in the method existing in the literature review.

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