Segmentation of the Region of Defects in Fruits and Vegetables

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***Abstract*— Diseases in fruits and vegetables cause significant production and economic losses in agricultural industry worldwide. Continuous monitoring and detection of defects in fruits and vegetables is critical for sustainable agricultural production. Thus, in recent years image processing and vision based techniques have been applied increasingly for fruits and vegetables diseases identification, which is very important to optimize the business profit and able to take necessary attempts for preventing such diseases from occurring in future. In this paper, we describe a computer vision-based approach for segmentation with a view to identify defected regions from various fruits (apple, banana, etc) and vegetables (potato, tomato, etc). We also investigate different segmentation techniques to select better one.**

Keywords- K-Means Clustering, segmentation, Otsu method, thresholding, defected region.

I. INTRODUCTION

Agriculture is still playing an important role in socio-economic development of most of the countries of the world. However, diseases are always hampering in the optimum agricultural production causing huge economic loss [1]. Controlling the diseases in fruits and vegetables is a challenging task. Early detection is necessary for farmers to avoid unwanted economic loss. Usually, for detecting diseases of fruits and vegetables farmers as well as experts use the classical approach which is based on the unaided eye observation. In most of the developing countries, due to the distant locations, consulting with experts become expensive and time consuming. Hence, automation is important to detect disease symptoms at an early stage [2].

Though in horticulture or agriculture science it becomes a major challenging task to identify diseases at an early stage on the basis of internal and external symptoms. Due to advancement of science and technology images are considered as one of the important source of data and information for the automatic detection and recognition of diverse objects and situations. So, with the help of computer vision system, we can solve the detection of diseases in fruits and vegetables. In recent years, computer vision based system has been used in weeds detection, fruits and vegetables sorting, grains classification, food products recognition in food processing, recognition of medicinal plant and so on. After acquisition of images using camera image analysis techniques are applied to extract useful and important features that are necessary for further processing [1, 3, 4, 5].

For automating visual inspection many attempts have been done to identify diseases in fruits and vegetables using computer vision with respect to various image components such as size, color, intensity, and so on. However, defected region identification is still a challenging task due to varieties of skin color in fruits and vegetables, variability of defect types, presence of stem and so on [5]. Here, we propose an automatic method for identifying defected regions from fruits and vegetables using segmentation-based approach.

The remainder of the paper is arranged as follows. Section II contains literature survey. In section III describes the methodology of the automated process, simulation results and discussions are described in section IV, and finally, in section V overall conclusions are drawn.

II. LITERATURE SURVEY

To automate the visual inspection of defected regions of fruits and vegetables through image-based approach a lot of efforts have been done. Li et al. [6] proposed a simple threshold based approach for performing defect segmentation [6].Mehl et al. [7] used a spectral analysis for defect detection. To segment contamination of defects in an apple, a modified Otsu thresholding method is presented by Kim et al. [8]. Moreover, different types of spectroscopic and imaging techniques have been proposed for detecting and indentifying symptomatic and asymptomatic fruit and vegetable diseases. For example, fluorescence imaging method was proposed by Bravo et al. [9], infrared photography was applied by Spinelli et al. [10], nuclear magnetic resonance (NMR) photography method was proposed by Choi et al. [11]. A review on multiple sensor-based methods is done by Hahn [12].

Li et al. [13] proposed an approach based on lighting transformation for detecting surface defects on oranges, but could not able to differentiate between defect types. Bennedsen et al. [14] described an approach for locating defected regions of apple image and eliminating other dark areas. However, it is applicable for only gray images. Moreover, they also stated a system of sorting apples for defects on surface, including bruises which had 78%-92% accuracy [15]. Besides, Shiv Ram Dubey et al. [16] proposed an infected part detection method based on k-means clustering. To investigate biological processes in orange trees Marcassa et al. [17] have applied fluorescence photography induced by laser. They have investigated diseases produced by the Bacterial canker of citrus (Xanthomonas campestris pv. citri) through comparing healthy and contaminated leaves. However, they were unable to discriminate it from another disease.

III. METHODOLOGY

In the proposed system architecture, we acquired images of different types of fruits and vegetables using external device such as camera. Then the whole process of infected region identification is divided into two distinct steps: pre-processing and segmentation. In pre-processing, we remove noise which can be occurred during image acquisition and enhance image contrast. After that for the detection of infected regions we use segmentation technique. Here, we use different segmentation techniques and compare them to select the better one. The typical block diagram of the whole methodology is given below:

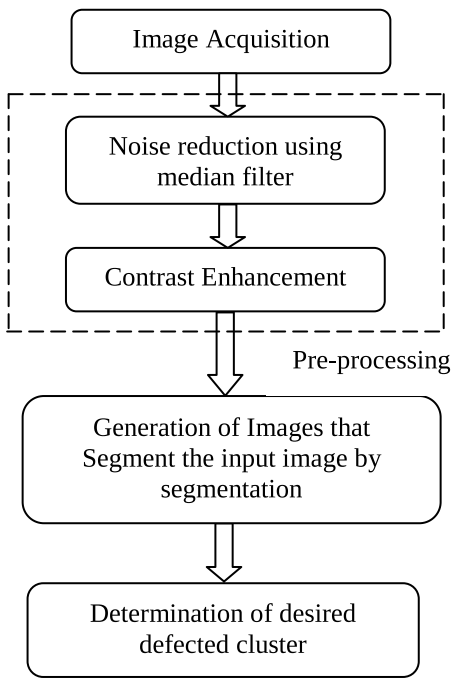

Figure 1: Block diagram for the segmentation of defected regions from images of fruits and vegetables.

A. Image Acquisition

In digital imaging, image acquisition is the process of acquiring an image from some hardware-based source, so that the output image can be used for further processing. The ultimate goal of image acquisition is having an input source which can be operated under controlled and measured guidelines that the same image can be used for locating defected regions and also for classifying the disease types [18]. In this paper, we have acquired images of fruits and vegetables on the same view.

B. Pre-processing

One of the sub-fields of image processing is pre-processing through which image quality can be improved for extraction of quality features for further processing. In this paper, the whole pre-processing process consists of two distinct stages.

i. Noise reduction using median filter

Digital images can be affected through noise during image acquisition. Thus, noise reduction is essential for the accuracy of further processing. Here, for this purpose we use a non-linear filter known as median filter. It is widely used under certain conditions where preservation edges are required. Median filter can effectively remove 'salt and pepper' type noise which occurs due to imaging hardware.

ii. Contrast enhancement

Contrast enhancement is used to eradicate the problem of lighting to improve the subjective quality of images for human interpretation. Image contrast is a significant factor created by the difference in luminance reflection from two adjacent surfaces. It often used for making distinguishable an object from other objects as well as background. According to visual perception, it can be determined through color and brightness of the object. In this paper, we use histogram equalization to enhance image contrast through redistribution of image intensity.

C. Image segmentation

The first and most difficult task of image analysis is image segmentation. The main objective of image segmentation is to extract information from image which is represented in the form of data. The overall extraction process can be conducted through segmentation of image, measurement of image features, representation and reconstruction of objects and so on [19]. Image segmentation is basically the process of clustering image pixels into salient regions for the convenience of perceiving. It is the process of separating or grouping an image into different parts. Since according to color, digital images can be divided into two types: gray and color images. Thus, segmentation of color image is totally different from gray images. Also which algorithm is robust and works well is depends on the type of images. Edge detection, thresholding, region growing methods, color based segmentation etc. are the widely used segmentation techniques used by most of the researchers [20]. In this paper, we use color-based segmentation for detecting infected area using K-means clustering, modified K-means clustering and Otsu method. From the visual inspection for the identification of diseases of some fruits and vegetables K-means clustering is better than the Otsu method. Similarly, it can be happened vice-versa.

i. Color-Based Segmentation Using K-Means Clustering

Color is one of the most widely used visual features. Here, color-based segmentation. At first we need to convert RGB into L*a*b color space and then apply K-means clustering. In L*a*b* space 'L*' means luminosity layer, 'a*' and 'b*'

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indicate chromaticity-layer where color falls along the red-green and blue-yellow axes, respectively. Moreover, 'a*' and 'b*' layers contain all of the color information. Here, for measuring distance of two colors Euclidean distance metric is used. Again, for extracting group of objects K-means clustering is applied. Algorithm based on color based segmentation using K-means clustering is given below [5]:

1. Read input RGB image.
2. Convert RGB color space into L*a*b color space.
3. To separate groups of objects, classify colors using K-means clustering in 'a*, b*' space.
4. All pixels in image are labeled from the results of K-means which returns a corresponding index to a cluster.
5. Generate images that segment the labeled image from step 4 by color.
6. Select appropriate segment that contains disease.

ii. Modified Color-Based Segmentation Using K-Means Clustering

Here, we use HSV color space instead of L*a*b. i.e. RGB input image is converted into HSV color space which separates luminance or the image intensity, from chroma or the color information. Here, 'H' belongs to 'Hue' representing an angle in the range $[0,2\pi]$ with respect to the red axis with red at 0 angle, green at $2\pi/3$, blue at $4\pi/3$ and red again at 2π[30], [31]. 'S' indicates 'Saturation' for describing the purity relative to a white reference. Again, 'V' stands for 'Luminance Value' which express a percentage from 0 to 100 [21].

From the empirical observations we found that, both two segmentation algorithms do not work fine for all fruit diseases detection. For example, in case of apple, there are different types of diseases like scab, apple rot, and apple brown and so on. Modified color based segmentation works fine for apple scab whereas color based segmentation works fine for other diseases.

iii. Segmentation and Infected Region Detection using Otsu Method

For performing automatic clustering based image segmentation, Otsu method is usually used. Again, Otsu method often applied in gray image by separating two classes of pixels (foreground pixels and background pixels) to minimize their combined spread or to maximize their inter-class variance. But in this paper, we use natural color image for detecting infected regions. Thus, the whole detection processing using Otsu method is mentioned below:

1. Read input RGB image.
2. Convert RGB image to corresponding gray image.
3. Apply Otsu method to cluster the gray image into three clusters.
4. For gaining only black i.e. infected regions from the output gray image after applying Otsu method, we will fill all pixels with white color value except infected regions. Now we have gray image with only infected region.
5. As our input image is RGB image, it is desired that output image will also be RGB. Thus, we compare original input image with output gray image to find the color values of pixels of infected regions. The final output image contains only infected regions which can be used for further diseases identification and classification.

IV. Simulation Results And Discussions

To determine the performance through experimental procedure, first we need to prepare the data set of infected fruits and vegetables. As our goal is to detect infected regions of diseases, thus we need to collect the images of different fruits and vegetables which are affected by different diseases. We have taken 25 images of apple diseases (apple scab, apple rot and apple blotch) for segmenting the defects. 15 images for banana diseases, 8 images for tomato diseases and 15 images for potato diseases. All images are collected from web. Figure 2 shows some sample images of infected fruits and vegetables. Figures 3, 4 and 5show the result of segmentation using K-means clustering, modified K-means clustering and Otsu method, respectively. Moreover, Figures 6, 7 and 8 show the comparison of output results of these three types of segmentation technique on banana, tomato and potato images, respectively.

According to visual inspection, we can see that defected area detection based on modified k-means clustering and Otsu method gives better result than k-means clustering. However, Otsu method is better than the modified k-means clustering as it separates the background of the image. For comparison, we have extracted ground truth manually using 'Sefexa' - an image processing tool. Fig. 9 and Fig. 10 show the performance results of different approaches along with ground truth. Table I shows the number of infected pixels in the original images of Fig.3 and Fig. 8 along with the number of pixels in the defected regions using different segmentation methods.

TABLE I

Number of Pixels			
Ground-truth	**K-means clustering**	**modified K-means clustering**	**Otsu method**
11019 pixels	17474 pixels	9907 pixels	9709 pixels
47451 pixels	43108 pixels	39520 pixels	49640 pixels

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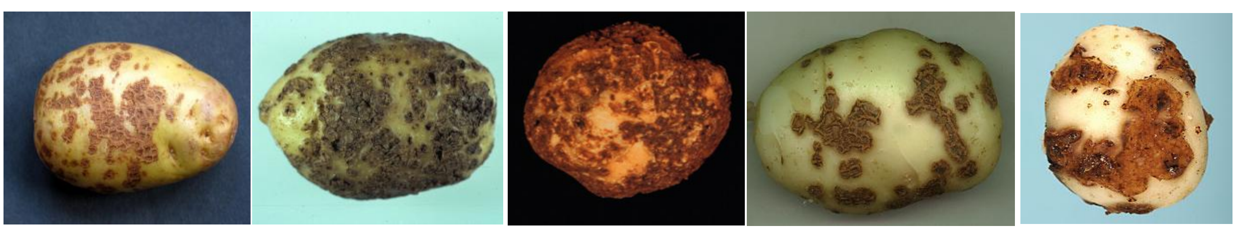
(a)

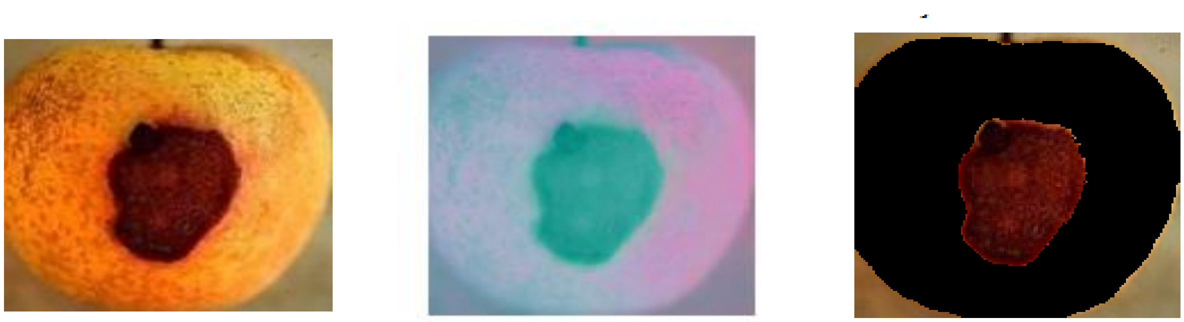
(b)

(c)



(d)

Figure 2: Sample data set of infected fruits and vegetables; (a) apple images, (b) banana images, (c) tomato images, (d) potato images.



(a) (b) (c)

Figure 3: Experimental result based on segmentation using K-means clustering ; (a) Input RGB image of affected apple; (b) Image after transforming L*a*b color space; (c) Output image with defected regions.

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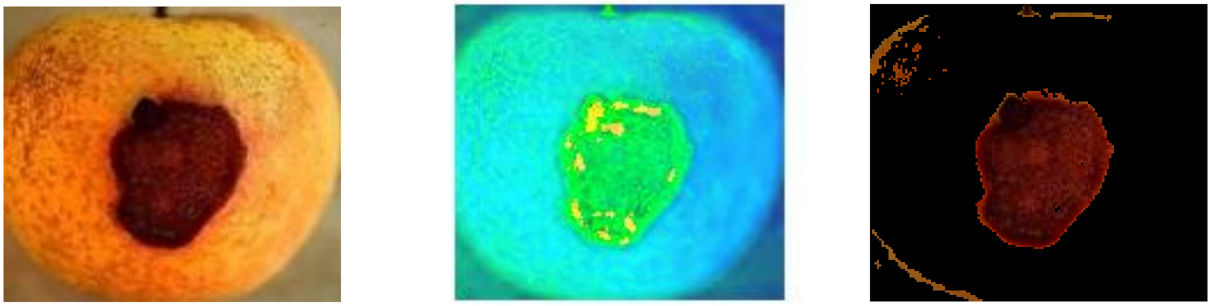
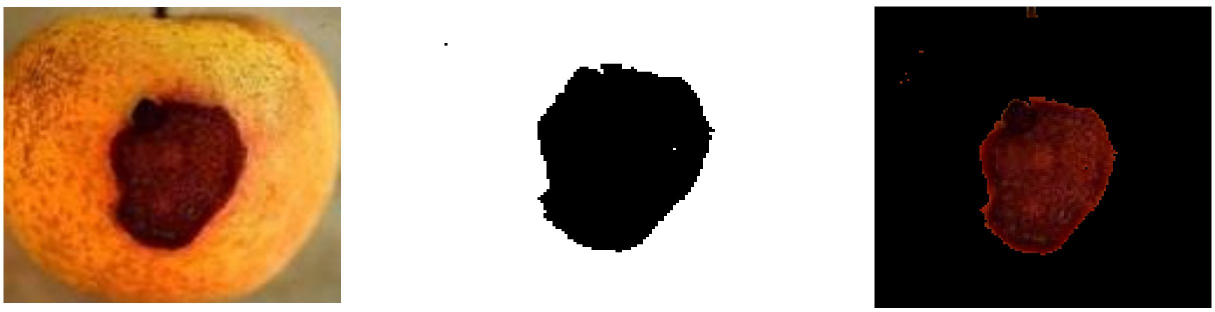


(a) (b) (c)

Figure 4: Experimental result based on modified color segmentation using K-means clustering ; (a) Input RGB image of affected apple; (b) Image after transforming HSV color space; (c) Output image with defected regions.



(a) (b) (c)

Figure 5: Experimental result of segmentation using Otsu method; (a) Input RGB image of diseases affected apple; (b) gray image after apply Otsu method; (c) Output image with defected regions after restoring the color information of input image.

(a) (b) (c) (d)

Figure 6: Segmentation of defected regions from banana image; (a) Input RGB image of affected banana; (b) Defected area segmentation using K-means clustering; (c) Defected area segmentation using modified K-means clustering; (d) Defected area segmentation based on Otsu method.

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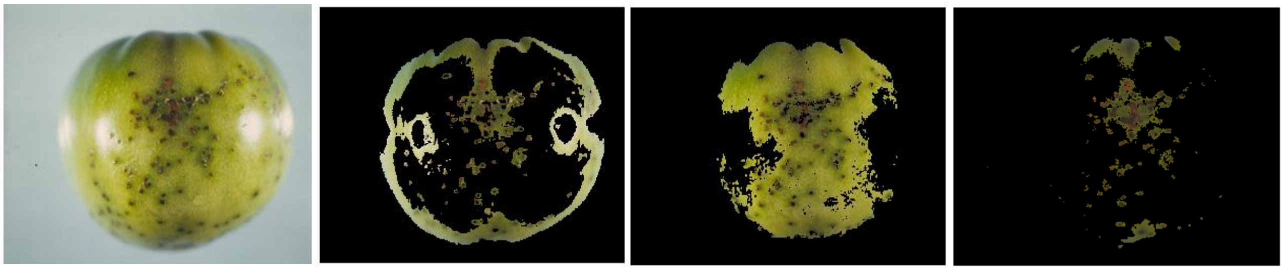
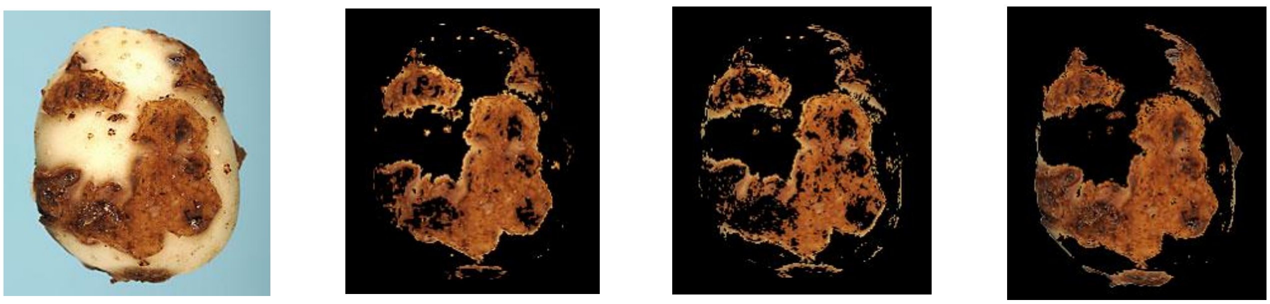


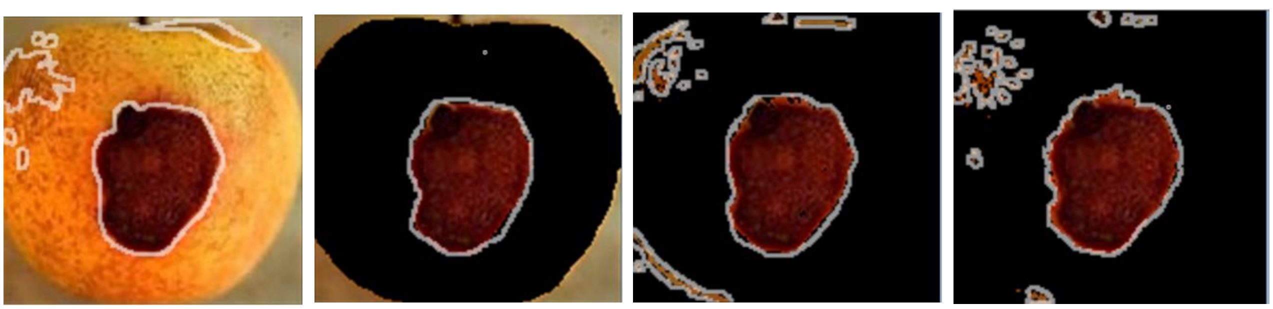
(a) (b) (c) (d)

Figure 7: Segmentation of defected regions from tomato image; (a) Input RGB image of diseases affected tomato; (b) Defected area segmentation using K-means clustering; (c) Defected area segmentation using modified k-means clustering; (d) Defected area segmentation based on Otsu method.



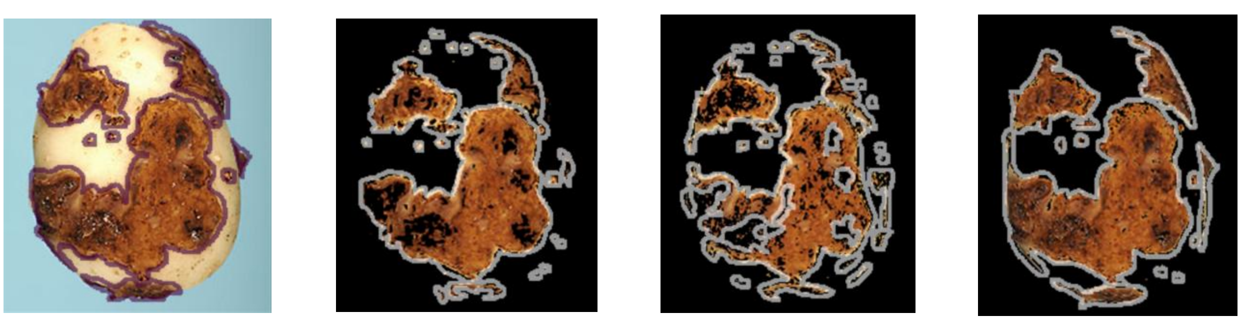
(a) (b) (c) (d)

Figure 8: Segmentation of defected regions from tomato image; (a) Input RGB image of diseases affected tomato; (b) Defected area segmentation using K-means clustering; (c) Defected area segmentation using modified k-means clustering; (d) Defected area segmentation based on Otsu method.



(a) (b) (c) (d)

Figure 9: Manual ground truth of original image and segmented image(a) Input RGB image of diseases affected tomato; (b) Segmentation using K-means clustering; (c) Segmentation using modified k-means clustering; (d) Segmentation based on Otsu method.



(a) (b) (c) (d)

Figure 10: Manual ground truth of original image and segmented image (a) Input RGB image of diseases affected tomato; (b) Segmentation using K-means clustering; (c) Segmentation using modified k-means clustering; (d) Segmentation based on Otsu method.

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V. CONCLUSION

A computer vision based approach is proposed for extracting defected area from fruits and vegetables. Using Otsu method it not only possible to extract infected regions but also remove the background from the input image. Further this method can be used for diseases identification using some machine learning technique which is essential for proper treatment of fruits and vegetables. Here we discuss color based segmentation using K-means clustering as well as modified approach. Also we apply Otsu method which gives better results compared to both K-means clustering. In future, we will try to identify diseases type on fruits and vegetables.

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