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AUTOMATED DETECTION OF FLAWS IN APPLE FRUITS

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Abstract

Image processing techniques have been used in fruit industry extensively. This shows great results in fruit sorting, classification, ripeness detection, and flaws detection and segmentation. Combining different image processing methods such as filtering, enhancement, and edge detection can provide good and promising results in fruit flaws segmentation. In this work, we attempt to detect the flaws in apple fruits by creating an algorithm based on image processing. This algorithm is a bunch of image processing techniques such median filtering, followed by image enhancement to remove noise from images and to increase their pixel intensities. Moreover, edge detection is used for finding edges of the flaws found in apple images. Image fusion is then used in order to contour the flaws found in apples by putting the segmented and original image on each other's. Finally, the system was tested on many images and it showed a good performance in finding and contouring the flaws in apple fruit images.

Keywords: Flaws detection, ripeness, segmentation, edges, filtering, image fusion.

Introduction

Food industry is a big field in which costly and huge machines are used to sort, pack, and classify fruits. Sorting, packing, and finding flaws in fruits require human effort which may need stress, hard work, and extensive efforts [1]. Consequently, this may come up with slow production as this can take long time. Therefore, there is a need for an image processing based system that can speed up this long process and facilitate the human work in fruit production industry [2]. Humans can take long time to check if fruits are healthy or have flaws. Thus, image processing that automatically detects flaws in fruits can facilitate work required by humans. Therefore, in this project we propose an image processing based algorithm to automatically and accurately detect flaws in apple fruits [3]. The system is a bunch of image processing methods that can end up by contouring the flaws in apple images. The images are first filtered using median filter in order to remove noise and enhance images. For pointing out the regions of interest, which are the flaws in apple fruits, the background of images are extracted and this leads to a blurring of the front of the image. Then, these backgrounds are added to the filtered original images which end up with images where the flaws are clearer and the other parts of image are blurred.

Moreover, these images are enhanced using contrast enhancement which increases the intensity of pixels leading to a better quality images. After pointing on the flaws and removing noises from images, edge detection for segmenting the flaws take place. In here, Canny operators was used due to its efficiency in detecting the edges in an image. After detecting the edges, image fusion is applied to segmented images which results in contouring the flaws in the original apple images. Experimentally, the proposed algorithm was evaluated on some healthy and defective apple images and the results are acceptable.

Literature review

Apple fruits diseases or flaws detection is a hot research topic. Therefore, many researches have been conducted in order to provide novel and new techniques for extracting features and detecting the diseases in apple images. Dubey et al., [4] proposed a new algorithm for segmenting defects in apples based on color components. The authors used k-means clustering which is an unsupervised algorithm used for classifying apples into healthy and defective ones.

Moreover, Donny et al., [5] worked on an algorithm for cropping the defective areas in apple images. the authors mainly used feature extraction techniques to do so. Different techniques were used for extracting useful features such as color invariant and Local binary patterns. Finally, the extrcaed features are used as inputs for an intelligent system that is trained to classify those features into good and bad or defective apples.

Another work proposed by Pujari et al [6] to detect and classify the apple images. This work is based on extracting the gray level co-occurrence matrix from input images. This technique (GLCM) is used to extract some texture features such as mean, saturation, intensity etc.. After extracting thee texture features, the authors used a technique to reduce the features from 30 to 2 which may speed up the classification process. The features are then fed into a neural network that learns to distinguish the features of each class and generalize the class of new apples. The authors claimed that the system performed greatly and an accuracy of 93.8% was achieved.

Automated detection of flaws in apple fruits

In this paper a computerized apples' flaws detection framework is produced. The framework is executed utilizing Matlab environment (Matlab 2013 programming devices). The framework depends on various image processing procedures utilized as a part of request to invigorate the human visual review for recognizing the flaws in an apple. The apple images (fig. 1) are gathered from the nearby market comprising of 40 natural products; 20 red apples and 20 green apples. Among these 20 images of every class, 10 are good image in which they have no flaws on their surfaces, while the other 20 images are bad images; with flaws on their surfaces. The images are changed over first to grayscale images, and afterward are filtered utilizing median filter keeping in mind the end goal to evacuate the commotion in an image and upgrade its quality. The background image is removed with a specific end goal to be at that point subtracted from the first one. Image alteration is connected to the come about image, along these lines builds its pixels force which clears that region of intrigue that is then divided in the following connected system; the edge identification utilizing shrewd administrator. In the wake of extricating the district of intrigue, the undesirable segments are expelled utilizing a calculation talked about in next section.

The last technique is to superimpose the removed ROI on the first grayscale image utilizing pixel level image fusion with a specific end goal to stamp the defect onto the first image. Fig.2 demonstrates our proposed framework calculation by setting progressively the strategies utilized.

(a) Good apple (b) Bad apple

Figure 1: good and bad apple images

Figure below shows the flowchart of the proposed image processing system for the detection of flaws in green and red apples.

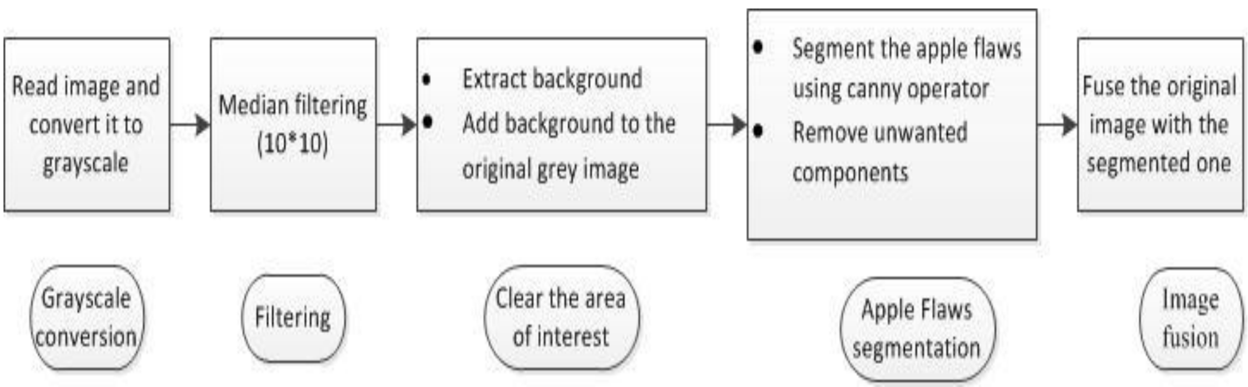

Figure 2: The proposed system flowchart

Fig. 3 is a case of our proposed apples' flaws discovery framework, in which a bad apple image experiences all beforehand examined image processing methods all together for the blemish's influenced region to be fragmented and afterward to check the area of enthusiasm on the first grayscale image utilizing image fusion. Similarly, fig. 4 shows a good apple image undergoes our proposed algorithm for the detection of flaws in apples' fruits.

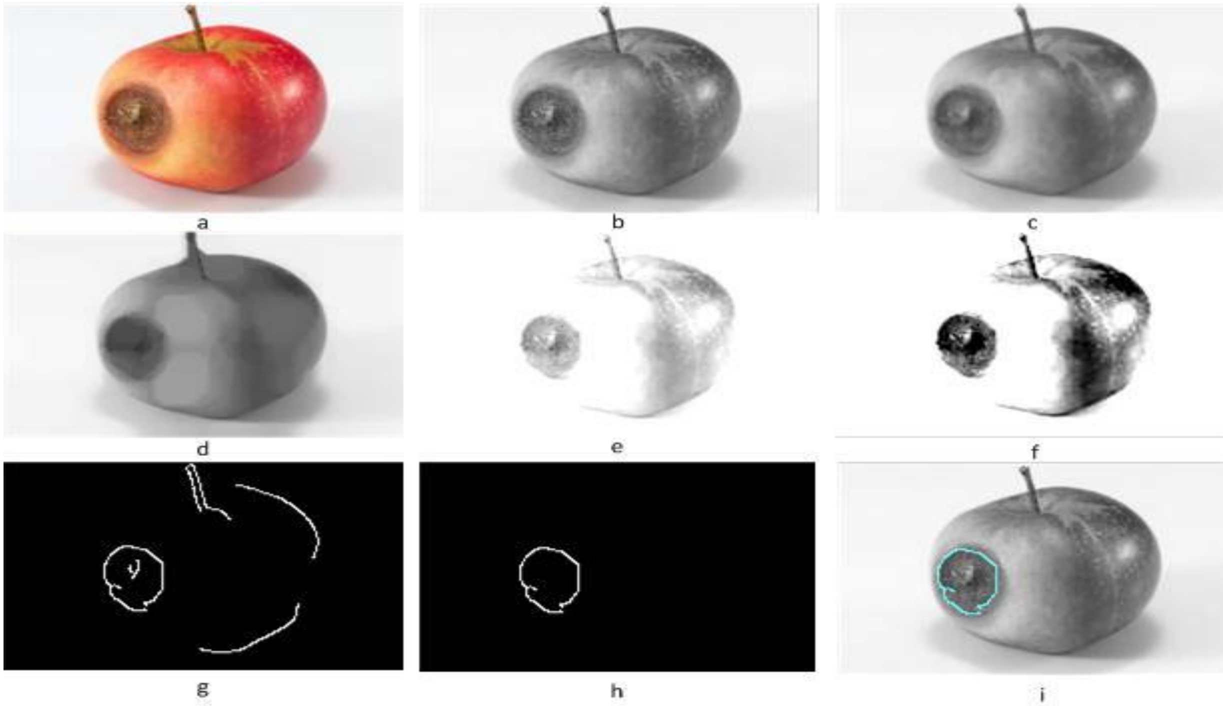

Figure 3: proposed system flaws detection in bad apple image

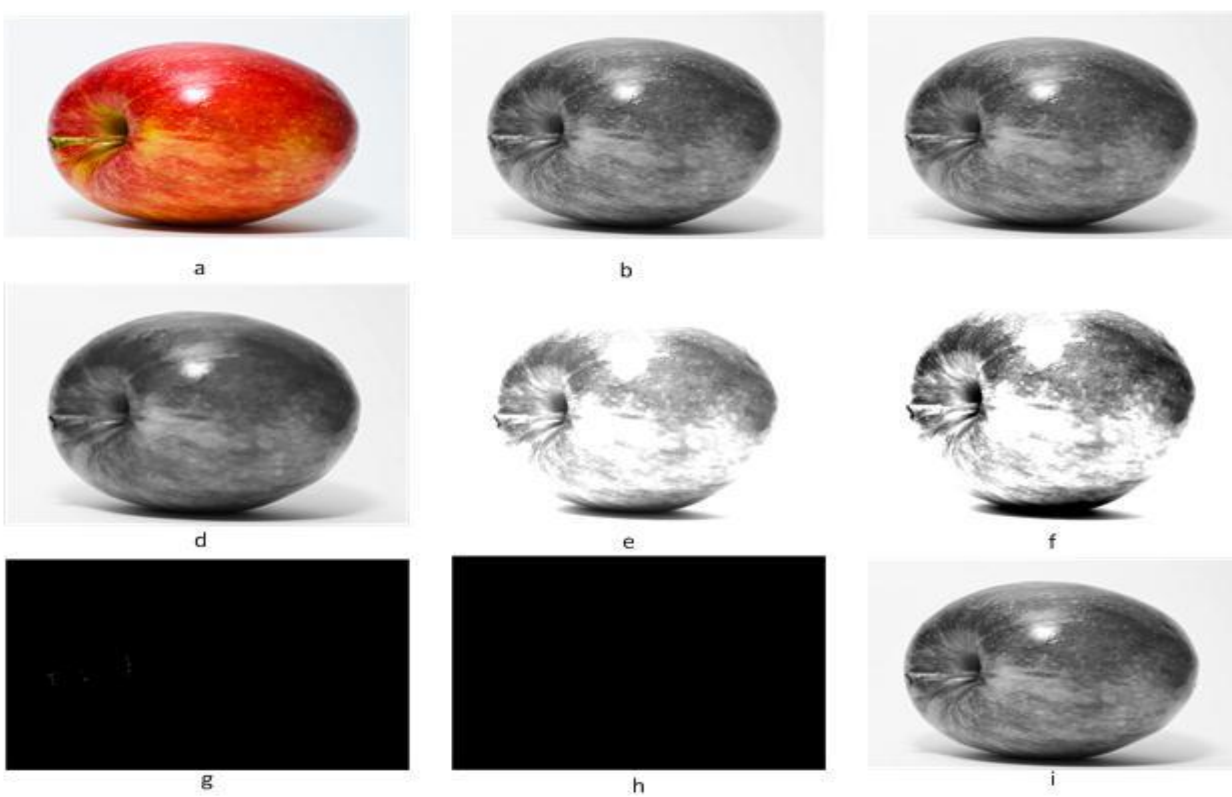

Figure 4: proposed system flaws detection in good apple image

2.1 Grayscale conversion

The initial step is to change image from RGB to grayscale. This transformation is done utilizing the luminosity technique which depends on the commitment of every shade of the three RGB colors [7].

Figure 5: Image grayscale conversion

Median image filtering

The median filter has been ended up being extremely helpful in numerous image processing applications. In a median filter, a window slides over the information and the median estimation of the pixel values inside the window is calculated to be the output of the filter. This nonlinear filter has more advantages comparing to linear ones since it helps in preserving edges. Moreover, it has the property of noise attenuation against the impulsive-sort noise [7,8].

The median filter considers every pixel in the image and takes a gander at its close-by neighbors to choose whether or not it is illustrative of its environment. Rather than essentially supplanting the pixel value with the mean of neighboring pixel values, it replaces it with the median of those values. The median is figured by first sorting all the pixel values from the encompassing neighborhood into numerical order and after that replacing the pixel being considered with the center pixel value. Figure 2 represents an illustration of the median value calculation of an apple image.

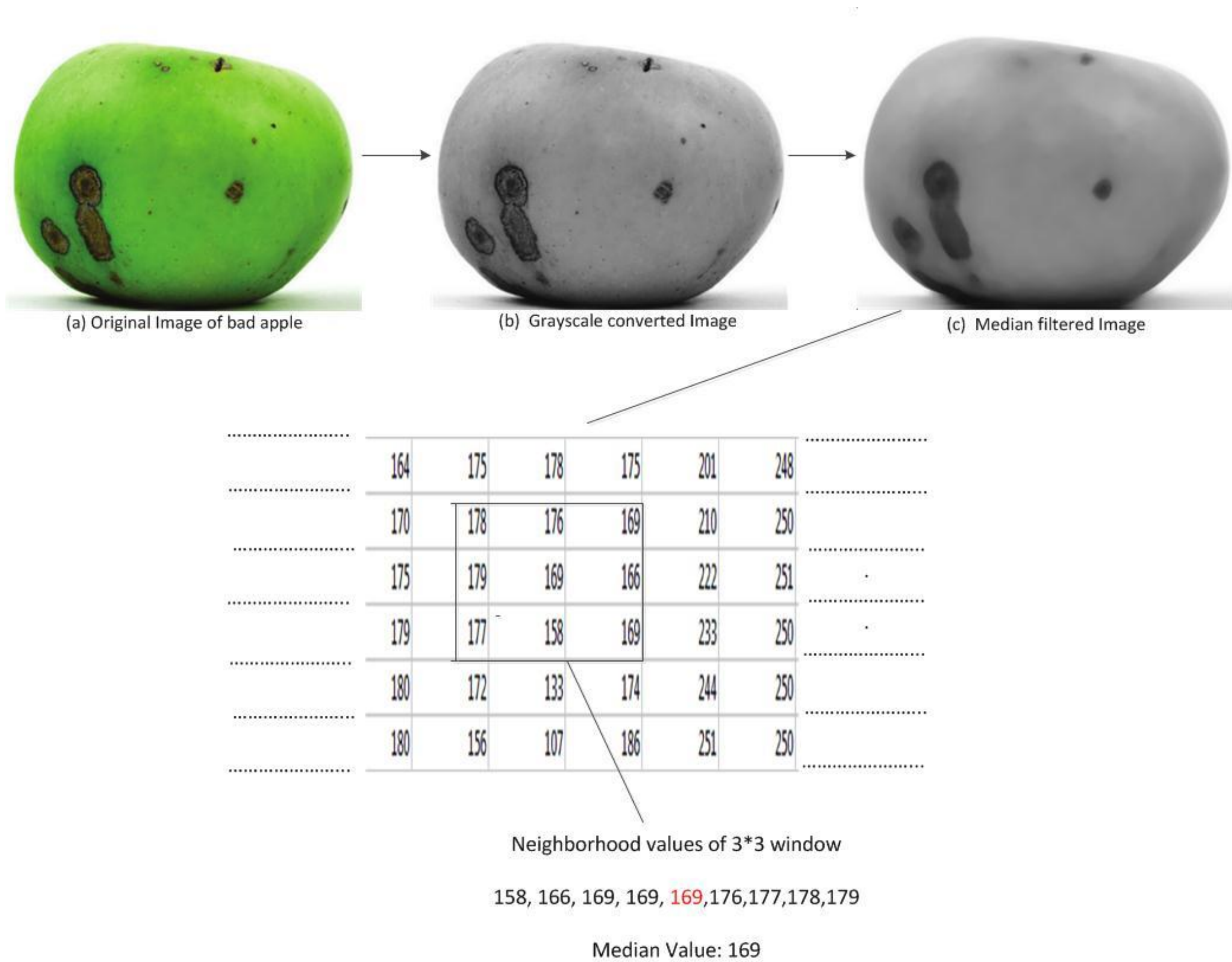

Figure 6: Median value calculation

Background extraction using image opening

Morphological operations are utilized for the separating of background of the image. Morphology can be characterized as set of image processing operations that procedure images in light of shapes [9]. These operations should be possible by applying a structuring element to an input image, bringing about an output image of the same size.

Morphological operations tests an image with a small shape or so called a “structuring element”. The structure element is a grid comprises of 0's and 1's, where the 1's are known as the neighbors The structuring element is placed at all possible locations in the input image in order to be compared with the corresponding neighbourhood of pixels. Thus, based on some operations it will be recognized whether the structure element fits or intersects within the neighbourhood as shown in fig. 7.

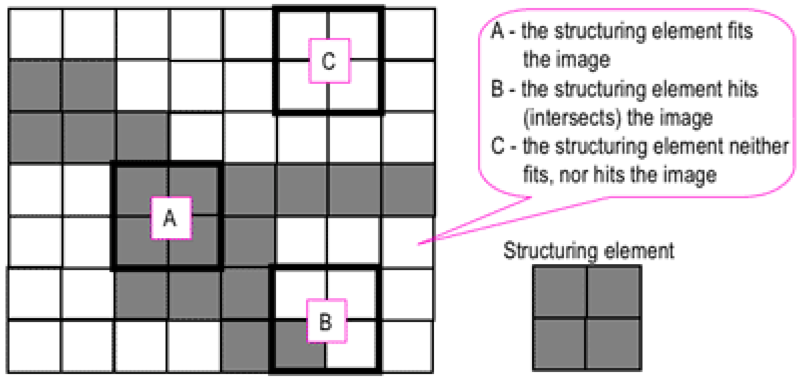

Figure 7: Probing of an image with a structuring element

Structure element has numerous shapes as indicated by its application. Here, the "disk" structure component with a radius of 15 is utilized to separate the background from the front image. The most well-known morphological operations are dilation and erosion. Image opening is utilized to extract the background of image in the proposed framework. Morphological opening is erosion trailed by dilation utilizing the same structure component for both operations. The opening method can uproot objects that can't totally contain the structure component all together then to separate the background [9, 10].

Dilation is used to respectively remove or add a pixel at object boundary based on structuring element shape and radius. Erosion is a change of shrinking, which diminishes the grayscale estimation of the image [5, 6]. The formula of finding the output pixel in both operations is the maximum of input pixels neighborhood matrix.

Image opening is used to extract background in the proposed system. It is erosion followed by dilation using the same structure element for both operations. Generally, it is used to smooth the edges of an image, in addition to remove gaps where the structuring element cannot be contained in order then to extract the background [9,10].

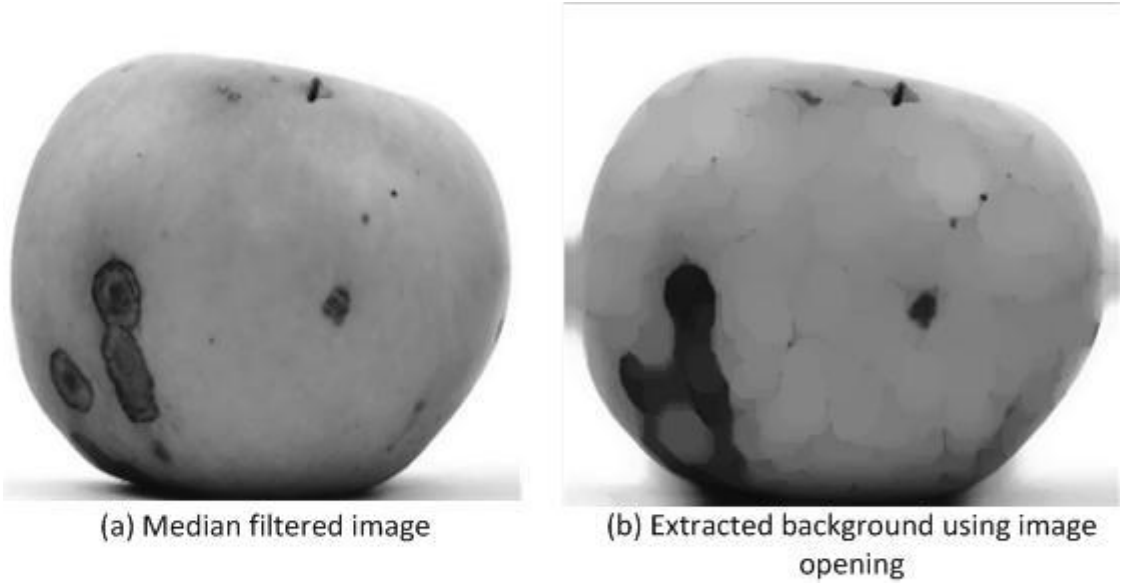

Figure 8: Background extraction

Images Addition

During this operation; the background image is added to original grayscale image. This addition operation is achieved by simply adding each pixel in the first image to its corresponding pixel in the second image [7]. This leads to an increase in the intensity of pixels; therefore, the region of interest (defective area) gets brighter since the pixels under this region originally have higher intensities than other pixels. Figure 8 illustrates the result image after adding the two images (original and background image).

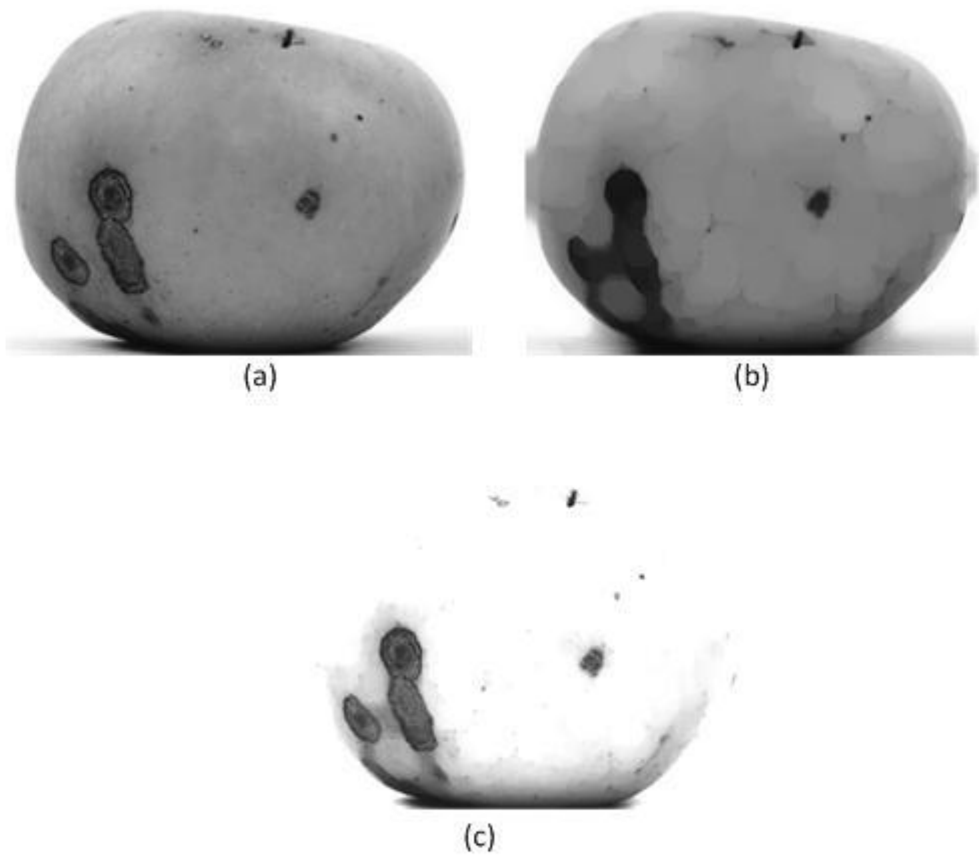

Figure 9: Image addition

It is remarkable that the output image gets brighter where the region of interest gets clearer and more defined, while the other ineffectual areas get marginalized.

Intensity adjustment

The image obtained from the addition of original and background image undergoes intensity adjustment in which the information image's intensities are mapped to another scope of intensities in the output image. This should be possible by setting the low and high information intensity esteems that ought to be mapped and the scale over which they ought to be mapped (fig. 10) [11].

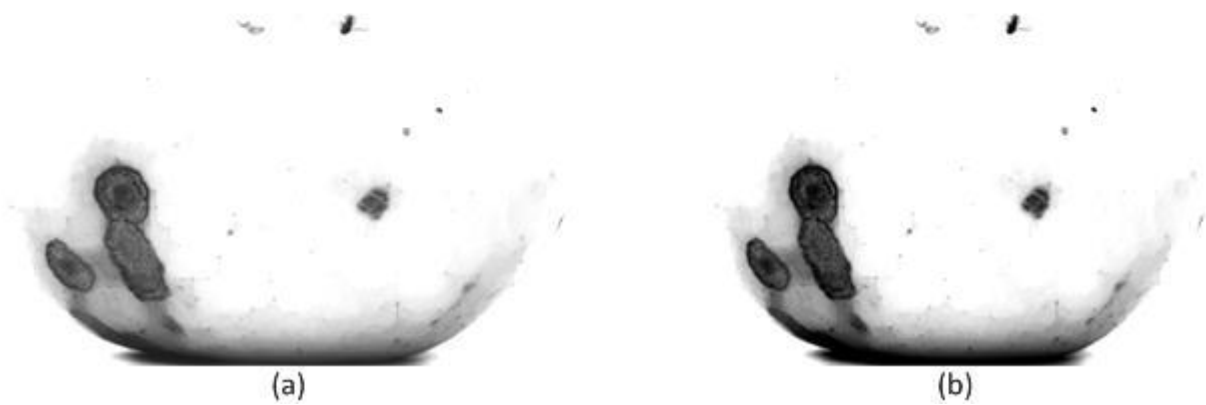

Figure 10: Image adjustment

It is also remarkable here that the flaws region (the region to be detected) is more identified after mapping the intensities of the image into a new range of intensities.

Edge detection

Edge detection can be defined as an image processing technique for finding the boundaries of an object in an image. Basically, this technique works by detecting the discontinuities in the intensities of pixels. This allows to detect the edges which are the discontinuities in intensities between two pixels [9,11]. Edge detection can be used for segmentation of objects in images and also for data extraction from images. Many algorithms were proposed for edge detection; each is used based on the application. However, the most common used is called Canny edge detection in which image are filtered and then edges are detected.

In this work, Canny detector is used for detecting the edges of the flaws found in the adjusted images. Figure 11 shows the canny edge detection of the adjusted apple image.

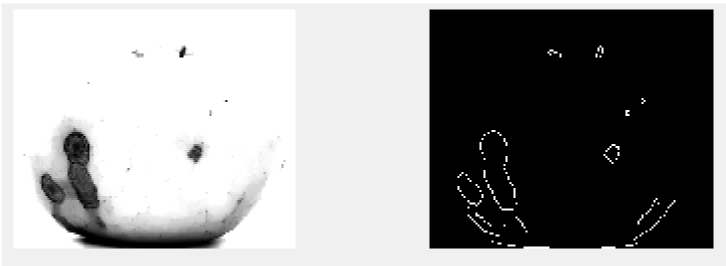

Figure 11: Detecting edges

Image fusion

Fusion can be defined as extraction the information from one image. image fusion means merging of information acquired from two or more images and combine them together all in one images which results in a new image called Fused images that contain all useful information from both used images [11].

Image fusion was used in many big areas such as medical imaging, remote sensing etc…for instance image fusion is the main core of the big medical imaging machine PET-CT. in this machine image fusion is used to merge two modalities images to come up with a more explanatory image called PET-CT image [10].

In our research, image fusion was used to combine two different images of different types. Edge detected image is fused with the adjusted image in order to impose the edges on the flaws found in the adjusted images. This can be seen as contouring of the flaws or defective areas in apple images. Figure 12 shows an example of image fusion for apple flaws detection.

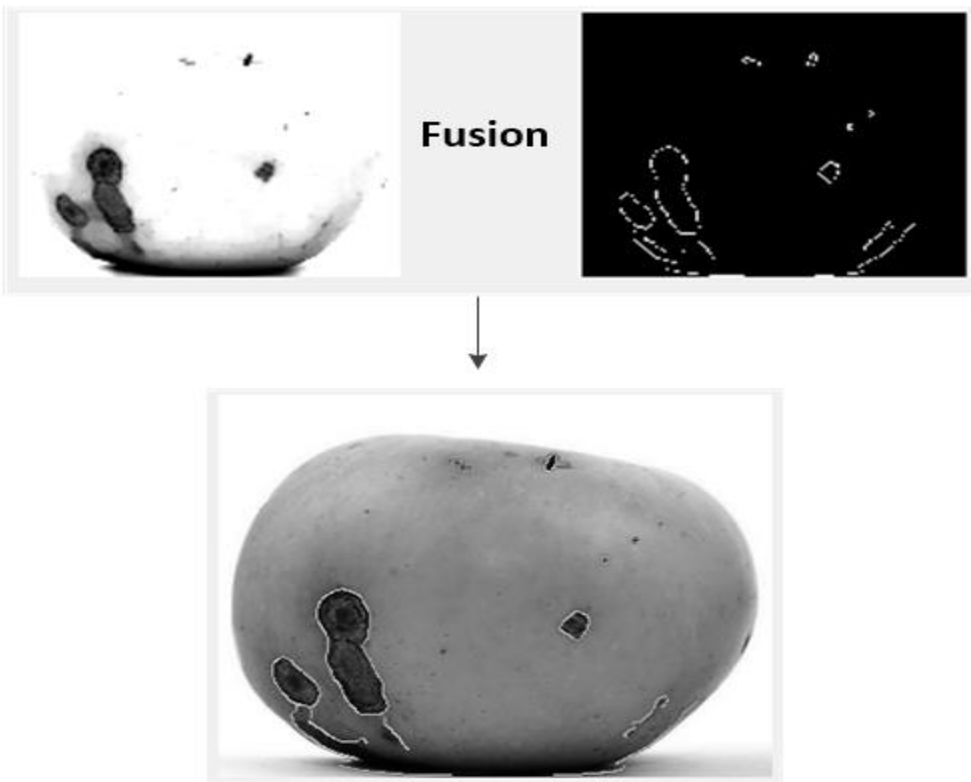

Figure 12: Image fusion

Conclusion

In this work, a flaws detection based image processing techniques is developed. the system is about detecting and contouring the flaws in an apple image using image processing techniques such as edge detection and image fusion. The system showed a good efficiency in detecting the defective areas in apples. Finally, it can be seen that these types of systems are really need in the food industry areas where highly cost machines and lot of human efforts are used to sort and detect the healthy and defective banana. Thus, due to the progress in science and image processing there should be a system that automatically detect flaws and take some duties out of humans.

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