IMAGE PROCESSING TECHNIQUES FOR CACTUS (BELES) DISEASES DETECTION (IMPLEMENTATION AND ANALYSIS)

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Abstract

This experimental analysis is conducted on Cactus (Beles) image to investigate better image enhancement, noise filtering and segmentation techniques. To find out this, different image enhancement, noise removal and segmentation techniques are identified and implemented to select the better one. As a result, imadjust() technique (algorithm) is selected to be the brightness enhancement technique, guided filter to the best noise removing technique and color based K-means clustering better segmentation technique for our data (cactus image).

Keywords: k-means, Markov Random Field, Feature, MSE, PNSR

1. Introduction

Image is a two dimensional function which is made of 256 pixels. Image is very important data in various, such as medical imaging, industries, geodesy, etc, researches and applications. In order the image to be used for applications (object detection, traffic analysis, medical images analysis etc), it must be preprocessed. Image processing is the use of computer algorithms to enhance its brightness, remove unnecessary data on the image that can affect the quality of the image and segmentation of the image into its sub constituents [1]. Therefore, image processing includes image compression, cropping, enhancement, noise filtering and segmentation. Image processing is held to change the quality of the image for improving the pictorial information of the image and rendering the image so that it can be suitable for independent machine perception.

Digital image processing employs the following operations [2].

a) *Restoring the image* is processing the image and using its result for some application. This removes data errors, noise and geometric distortions that are mostly introduced during recording, scanning and the playback operations.

b) *Enhancing the image* is an operation in image processing which focuses on image sharpening, debluring, edges highlighting, contrast improving (increasing the brightness level of the image) and noise removal.

c) *Analyzing the image* is concerned with producing quantitative measurement from the image to make a description about the image. To do this, image analysis techniques are used to extract important features that can help in recognizing an object.

1.1 Applications of Image Processing

Since is most important information in different areas of research and disciplines, image processing is applied in different applications [3]. This is to mean that image processing is applicable in photo shop, space image processing, medical (Biological) image processing, automatic character recognition, finger print (iris recognition), remote sensing, industrial applications (product inspection/sorting or quality control), surveillance and security, face recognition, gesture recognition, space applications and autonomous vehicles and much more. Therefore, since image is applicable (important) in almost every discipline, image processing is used to have good result in the future activities (such as classification) to make accurate decision.

Since the image that will be used has to be processed, different image preprocessing techniques are used as discussed below.

1.2 Image Processing Techniques Used

This section discusses the techniques used (implemented using matlab R2015a) to demonstrate the results we have got. The techniques used in this article include image enhancement, noise removal (filtering) and segmentation techniques. These techniques will be discussed below one by one and the result of their implementation will be shown in the next sections.

1.2.1 *Image Enhancement Techniques*: Image enhancement techniques are used to improve the quality (visual appearance) of the image to suite it for analysis by human or machine [4]. This technique employs contrast manipulation (poor contrast enhancement), amplitude scaling (scaling an output image back into the domain of values occupied by the original image), contrast modification (deals about point transformations that modify the contrast of an image within a display's dynamic range) and histogram modification (the original image is rescaled so that the histogram of the enhanced image follows some desired forms). However, we have used the matlab R2015a **imadjust** function to enhance the contrast of our cactus images and their result will be shown (demonstrated) in the following sections.

1.2.2 *Noise filtering Techniques*: Normally, image noise is a disturbance or unnecessary data on the image that affects the deciding power of a machine, such as in object recognition, classification and detection. Therefore, to remove the noise on an image, different techniques are implemented the best one is selected to be a good noise filtering technique for cactus image. Although there are various types of noises, Gaussian, Poisson, speckle and salt & pepper noises are considered in this work. To filter these unnecessary data on an image, we have implemented mean, median, adaptive, guided, Gaussian and linear filters in our work. Before looking at their implementations and result, let us discuss what these filters are [5].

a) Mean (Average) filter: This is a linear filtering technique to remove images by replacing each pixel value in an image with the mean value of its neighbors including itself. However, mean filtering is poor in reserving the edges of the image. This technique is also thought as convolution filter because it is based around the kernel which represents the shape and size of the neighborhood.

b) Median filter: It is a non-linear filtering technique used to remove image noises. It is the most widely used filtering technique, especially for tasks that require edge preservation. Unlike the mean filter, the median filter preserves images' edges because sometimes noise removing is done to detect image edges to use for future activities that require edges. Therefore, median filter is important over mean filter because median filter is more robust and does not create unrealistic pixel values when the filter straddles an edge due to the reason that the median value must be the value of one of the pixels in the neighborhood.

c) Wiener (Adaptive) filter: It is a linear filter that de-noises an image that has a corrupted signal. It is a statistical approach that uses desired frequency response. A minimum mean squared error is the performance criteria of this technique.

d) Linear filter: It is used to remove certain noises and also blur sharp edges, destroy lines and other fine details of an image.

e) Gaussian filter: It is a linear filtering technique with a weight chosen according to the shape of its function (Gaussian function). It is a good smoothing technique for noises drawn from a normal distribution.

f) Guided filter: It is derived from local linear model to smooth an image. It is by far better to preserve edges of an image under noise removal [6]. This filtering technique involves a guidance image and output image.

1.2.3 *Segmentation Techniques:* According to [7], image segmentation is the process of partitioning an image in to important constituents (pixels or regions) to change the representation of the image into its meaningful and easier regions that can collectively cover the entire image. To do image segmentation, some feature, such as edge, color, shape, texture, etc are considered. Therefore, we have analyzed and identified the following image segmentation techniques as it can be seen in the implementation part of our work to segment cactus image.

a) Region Based Segmentation Technique: This technique segments the image based on the similarity of the characteristics of pixels of the image. This is to mean that pixels of similar characteristics are grouped to one to form one segment or the pixels with the same population mean and variance constitute one segment and the others too [8]. To summarize, in this segmentation technique each partition consists of pixels of uniform and homogeneous gray level, color or texture. There should not be holes. Adjacent regions of a segment must have different values with respect to the characteristics. Therefore, the implementation result of this type of segmentation will be seen in the implementation part below.

b) Edge Based Segmentation Technique: This technique considers the discontinuity and ending properties of an image to segment it into its constituents. Before segmenting the image, it must be enhanced and noises must be filtered. Therefore, edge based image segmentation employs many techniques (approaches or operators). There are many edge based image segmentation techniques. However, we have identified the below discussed techniques (edge detectors) in our work to select the better one. Their performances will be discussed in the implementation section. So, the used techniques are [1].

i. Roberts Detection: This technique detects high spatial frequency edges to do the segmentation. Its input and output is a grayscale image.

ii. Prewitt Detection: This operator (detector) is also entitled to estimate the magnitude and orientation of an edge to segment

the image. Although this method (algorithm) uses 8 possible orientations, most direct orientation estimates are not accurate.

iii. *Sobel Detector:* This technique is used to detect a high spacial frequency or approximate absolute gradient magnitude of a grayscale image.

iv. *Canny Detection:* This detector detects edges to segment the image considering that all edges must be found and the distance between actual edges in the image should be minimized.

v. *Laplacian Detection:* As other above mentioned techniques, it highlights regions of rapid intensity change to calculate zero-crossings of the second derivative to detect the edge.

c) *Feature Based Clustering:* According to [9], feature based clustering image segmentation technique uses the centroid to represent each cluster and base on the similarity with the centroid of cluster to classify. This method consists of around three algorithms, but we have used K-means color based clustering for our purpose.

d) *Model Based Segmentation Technique:* Model based segmentation technique employs Markov Random Field (MRF) [10]. This model combines image features and colors to segment the image. Hence, we have implemented and evaluated color based MRF model to see the results it gives.

2. Experimental Results and Discussion

This section discusses the implementation the image preprocessing techniques (algorithms). Each technique is implemented and demonstrated using matlab R2015a. The implementation of the techniques is depicted below along with its result supported by screenshots.

1.3 *Implementation of image enhancement technique:* since the brightness or contrast our image must be good, we enhanced it using **imadjust()** matlab function as its result can be seen in the screenshot below.

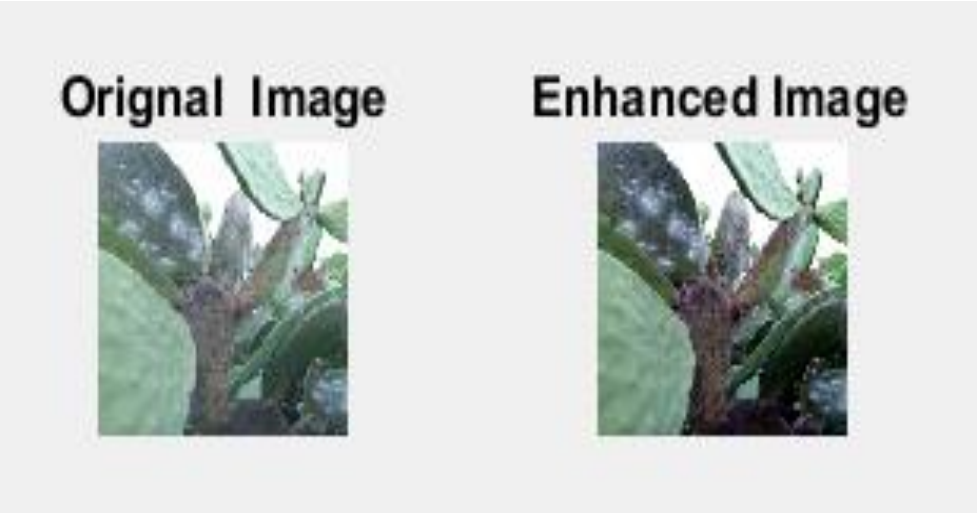

Fig 1: Cactus image enhancement

1.4 *Implementation of noise Filtering Techniques:* As it is discussed in the above sections, there are a number of noises and filtering techniques to remove the noise so as to have good data for further processes. In this task, mean, median, guided, Gaussian, adaptive and linear filters are implemented to remove Gaussian, salt & pepper, speckle and Poisson noises as it can be seen in the screenshots below.

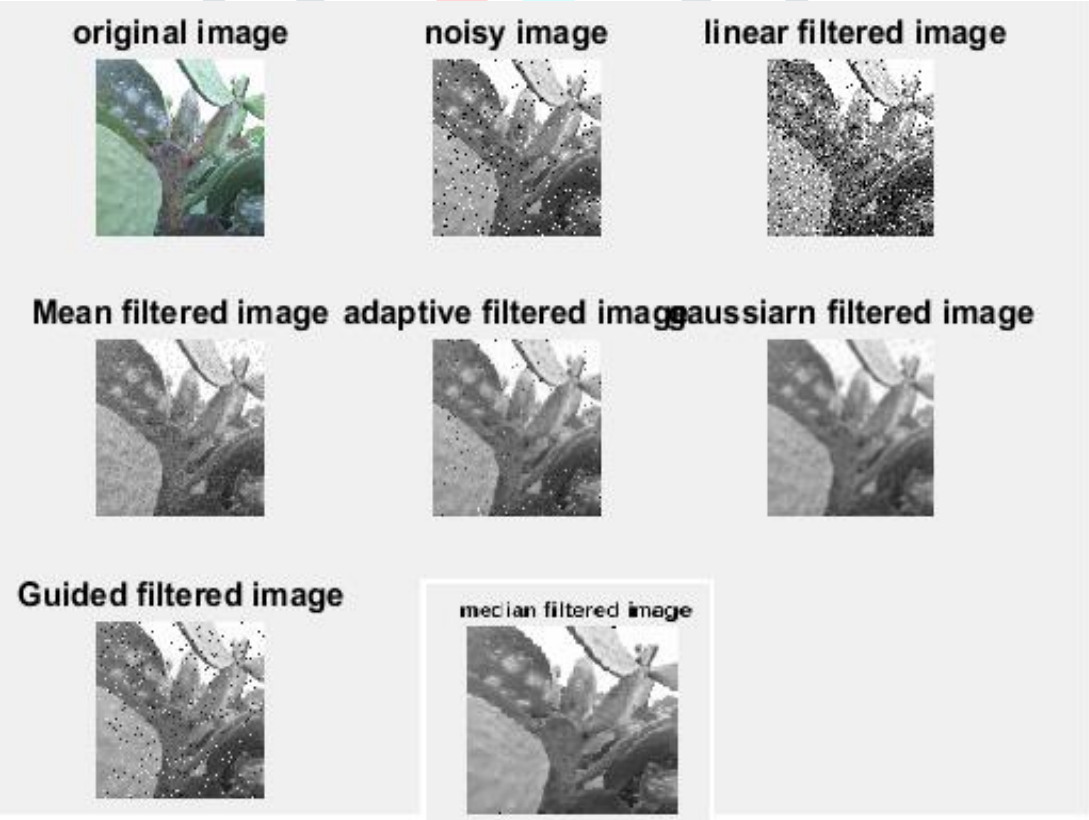

Fig 2: Salt & pepper noise filtering

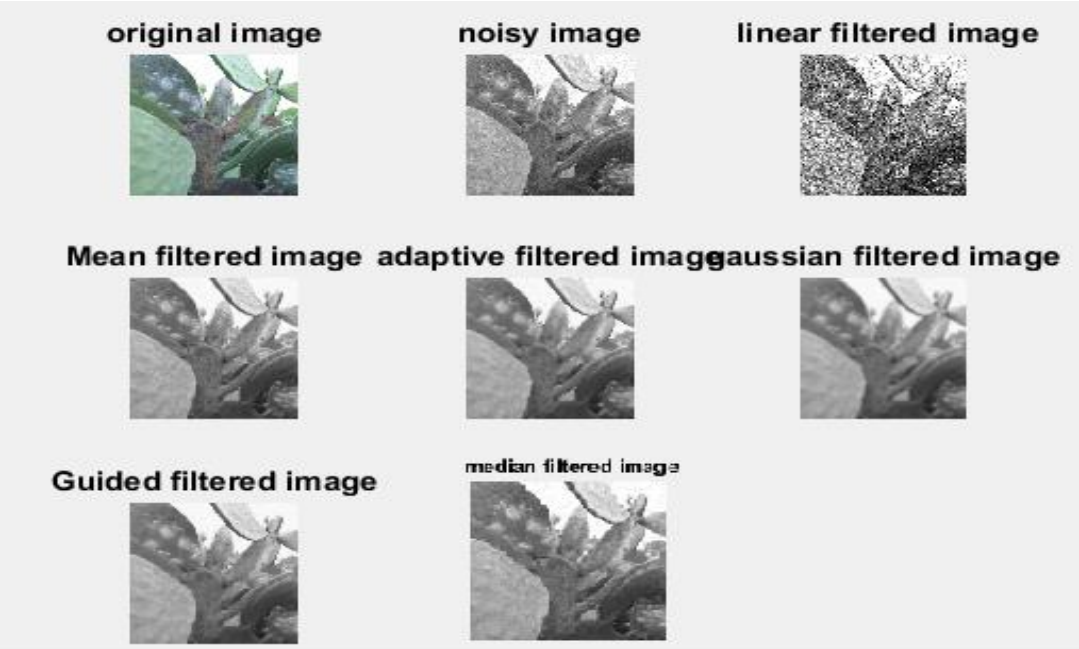

Fig 3: Poisson noise filtering

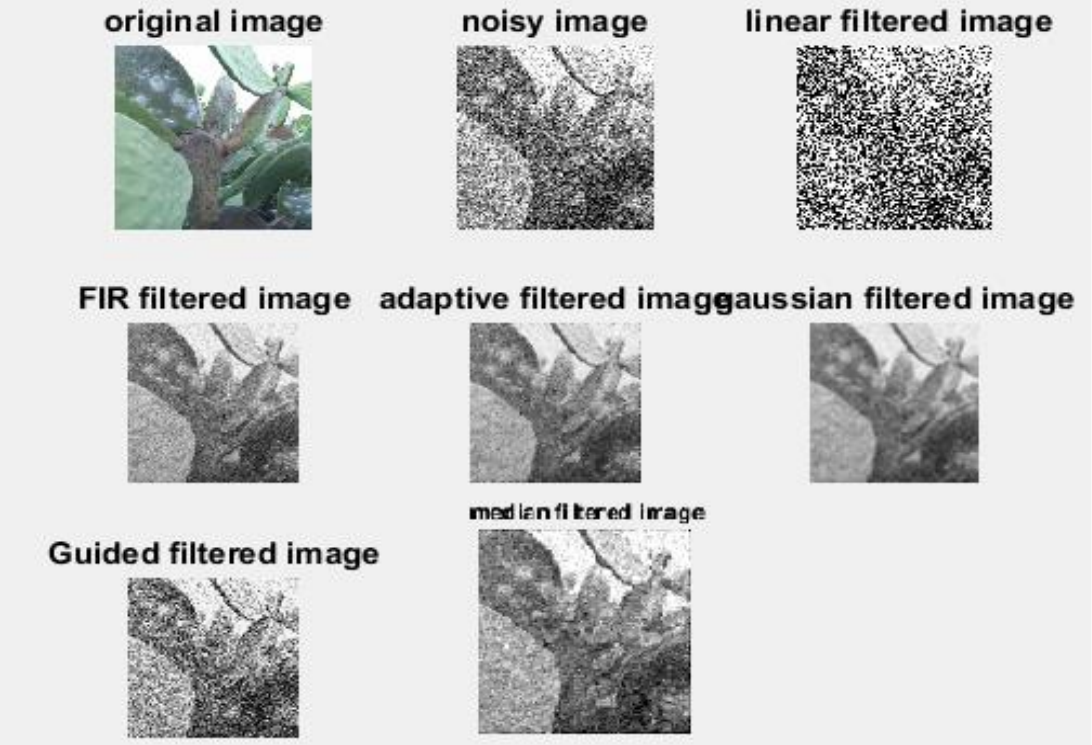

Fig 4: Gaussian noise filtering

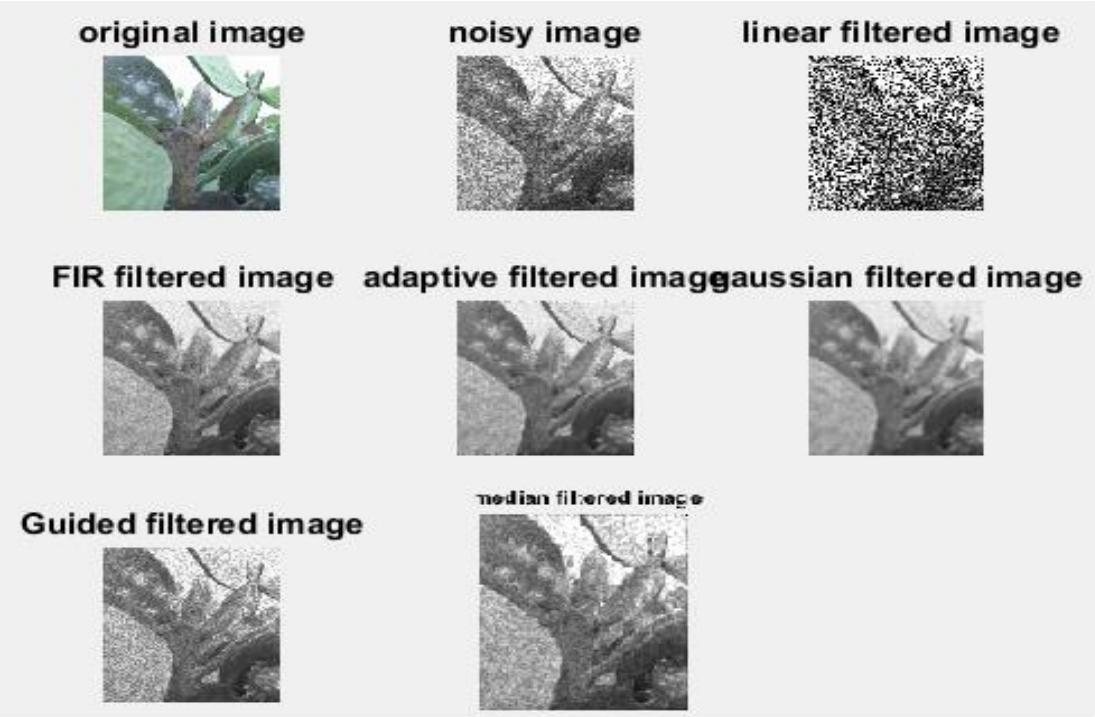

Fig 5: Speckle noise filtering

1.4.1 *Evaluation of noise filtering techniques on cactus image:* As it can be observed from the above results of noise filtering techniques for each noise, it can be difficult to select the best filtering technique for each noise. Hence, we have implemented quantitative measures to select the best one. As a result, we have used (implemented) MSE (mean squared error) and PSNR (Peak-signal to noise ratio) and shown the results in tables and bar charts. This is to mean that the quality of the noise removal algorithms is measured by MSE and PSNR values. The greater the PSNR value the better is the filter [11] and the smaller the MSE value the better is the filtering technique [12]. Therefore, as it can be seen from the table and the chart, guided filter has smallest MSE and largest PSNR values in removing each type of noise. So, this filtering technique is selected to be the best filter for cactus noise image.

Table 1: MSE results (values)

	Gaussian Noise	Salt & Pepper Noise	Speckle Noise	Poisson Noise
Mean Filter	25004.1408	24175.4816	23367.108	23564.2084
Median Filter	2595.2012	975.9528	951.7281	148.2695
Gausian Filter	2611.6994	993.0976	983.0382	241.3524
Guided Filter	97.6365	91.7925	132.1344	91.7369
Adaptive Filter	2100.7379	503.1769	722.2088	156.6755
Linear Filter	4918.1642	1268.1684	4906.1714	1703.6667

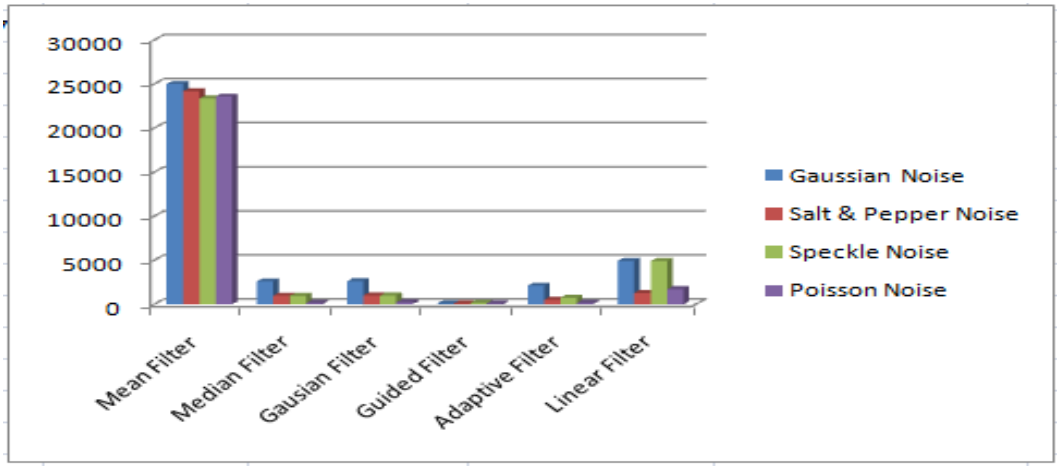

Fig 6: MSE values distribution in chart

Table 2: PSNR results (values)

	Gaussian Noise	Salt & Pepper Noise	Speckle Noise	Poisson Noise
Mean Filter	13.3832	16.9864	17.2212	21.7396
Median Filter	13.9651	18.1805	18.3465	26.4643
Gausian Filter	13.9354	18.0122	18.2273	24.3423
Guided Filter	28.2524	28.4884	26.9144	28.515
Adaptive Filter	14.8814	20.972	19.5568	26.1925
Linear Filter	11.2572	17.043	11.2089	15.8239

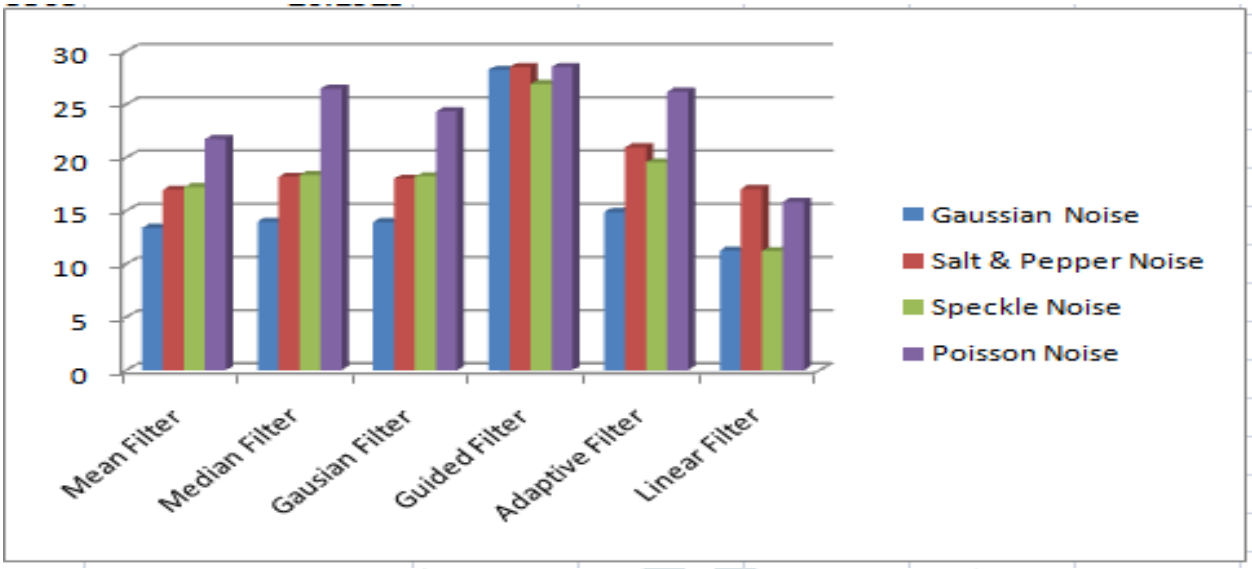

Fig 7: PSNR values distribution in chart

1.5 *Implementation of image Segmentation Techniques:* In the image segmentation above, we have discussed the image segmentation techniques. In this section, implementation of the techniques and their demo will be depicted. Finally, the best segmentation technique will be selected so as to be used for future activities.

2.3.1 Implementation of Edge Based Segmentation: Edge is important information in image processing. Therefore, Sobel, prewitt, Laplacian and Robert's edge based segmentation techniques (edge detectors) are implemented as it is shown in the screenshot below.

Fig 8: Edge Based Image segmentation

From the above implemented edge detectors, Sobel edge detector is selected as the best edge based image segmentation technique from the others because it has less discontinuity.

2.3.2 Implementation of Region Based Segmentation Technique: This method is based on pixels' similarity and its implementation results the following screenshot.

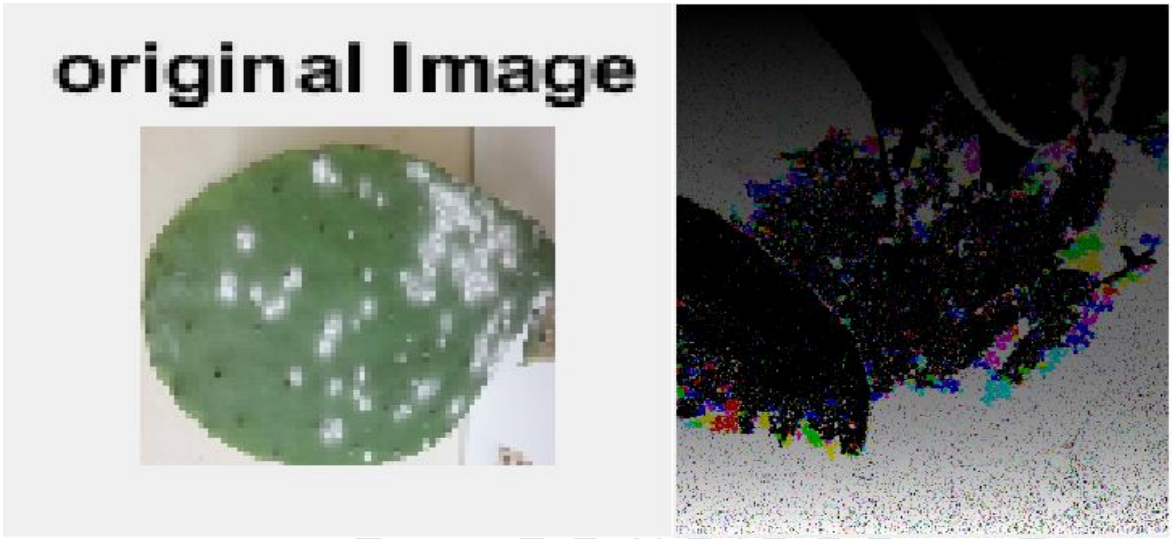

Fig 9: Region Based Image segmentation

2.3.3 Implementation of Model Based Segmentation Technique: As it is discussed in the above section, Model Based Image Segmentation Techniques employs Markov Random Field **(MRF)** to detect edges considering color as its demo looks like the following screenshot.

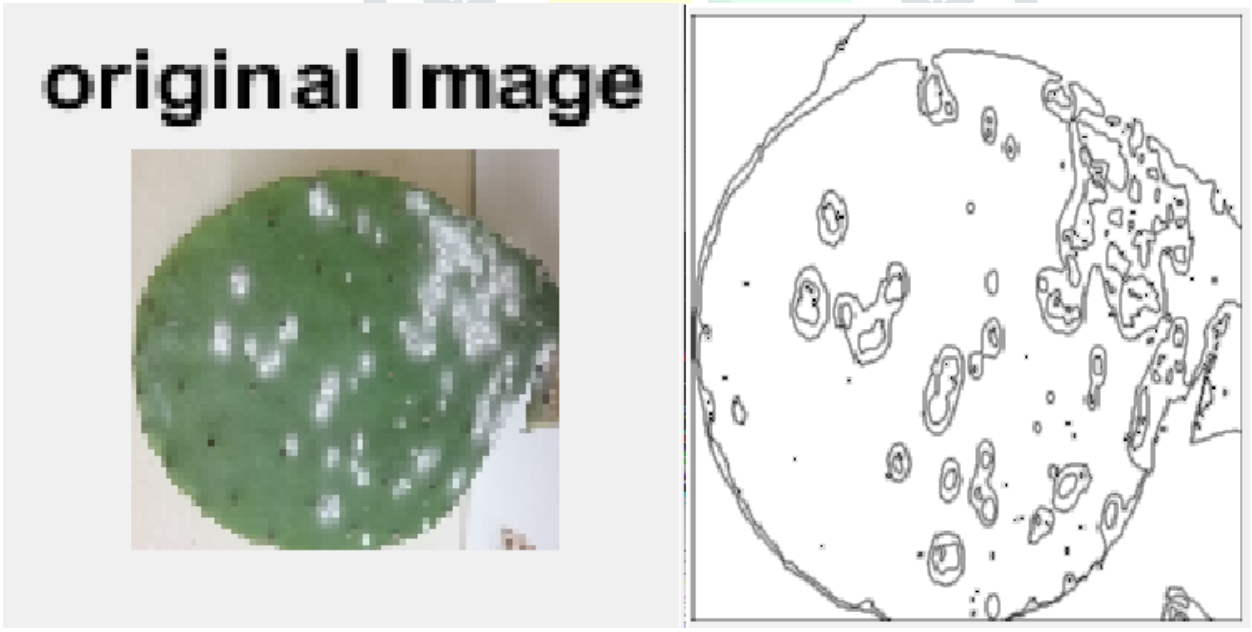

Fig 10: Model Based Image segmentation

2.3.4 Feature Based Clustering: This is also a segmentation technique that considers features (such as color, shape, texture, holes etc) to segment an image into desired parts. For this purpose, we have implemented color based K-means clustering algorithm as the demonstration below shows.

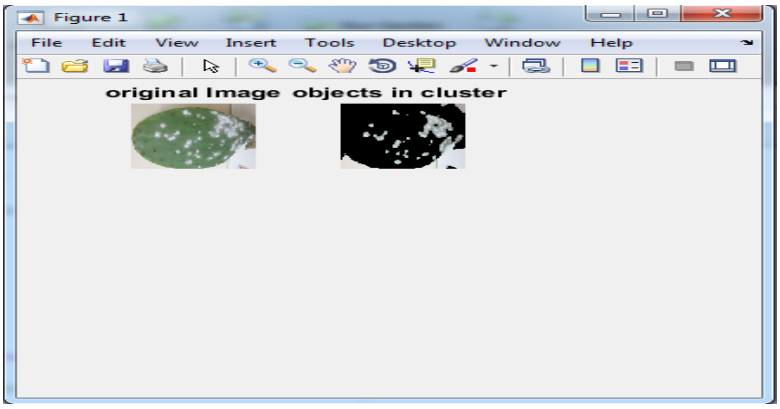

Fig 11: Feature Based (k-means clustering) Image segmentation

2.3.4.1 Evaluation of Image segmentation Techniques.

There must be a quantitative measurement to so that better segmentation technique will be selected. Therefore, for this purpose, correlation and structural similarity methods are implemented and color based K-means clustering (Feature Based Image segmentation) is selected as a better segmentation technique for our data (cactus image).

3. *Conclusion*

In this article, image preprocessing techniques, such as image enhancement, noise removal and image segmentation are identified and implemented on cactus image data. The demonstration of the results is also held. Finally, guided filter and K-means segmentation technique are found to be best filter and segmentation technique respectively.

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