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Comparing the Performance of Various Filters on Skin Cancer Images

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Abstract

Noise removing from an image is an important task in different applications such as medical which the noise free images could leads to less error detection. Filtering as a tool for noise removal is concerned in this paper. The purpose is to compare the performance of five filters - Median Filter, Adaptive Median Filter, Mean Filter, Gaussian Filter and Adaptive Wiener filter- for de-noising from Gaussian noise, Salt & Pepper noise, Poisson noise and Speckle noise.

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Keywords: Filters, Preprocessing, Skin cancer, Detection, Automatic Systems, Image Processing

1. Introduction

One of the most important tasks in image processing is to suppress the noise from images which have been corrupted by different reasons such as imperfection of imaging system, bad focusing, motion and etc. The noise removal techniques could assist to present the more precious characteristics of images which are not well understood [1]. It would be useful in different applications of fields such as astronomy, forensic science and particularly in medical field which need more reliable techniques to get the accurate outcome. Since selecting the de-noising algorithm depends on the application, therefore, the knowledge of noises in an image is essential to choose the suitable de-noising algorithm [2].

The point of focus in this paper is to compare de-noising techniques for images applied in automatic skin cancer detection. Five popular Filters are studied in this paper. We suggest to restore a corrupted image A defined by A = O + N, where O is the original image and N is an Additive noise, fig. 1.

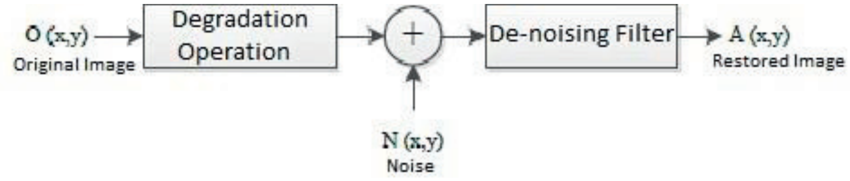

Fig. 1.Overall Process of Image Restoration

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The outline of this paper is the following. Section 2 includes the overview of Image Restoration methods which describe the effective filters and noises. In Section 2 in order to quantify the performance of various restoration algorithms, the noisy images are simulated by adding different types of noises into original image and then de-noised using different filters. The performance is evaluated by computing the peak signal-to-noise ratio (PSNR).The last step is to analyse and discuss about the results. Section 4 is the conclusion of the paper.

2. Overview of Image Restoration Methods

In this section, the paper briefly explain the existing noises in an image and also five well-known filters for removing the noise in image processing. The paper add four noises of Gaussian, Salt & Pepper, Poisson and Speckle to the Skin cancer image and then de-noise it using Adaptive Median filter, Mean filter, Adaptive Mean filter, Gaussian smoothing filter and Wiener filter to compare the best performance. The peak signal-to-noise ratio (PSNR) as one of the most appropriate indexes for comparison of two images is applied for determining the best effective filter. In the following the paper briefly explains the mentioned filters along with noises.

2.1. Filters

The filters are reviewing in the following:

- Median filter: Median filter is one of the most popular and efficient filters which is simple to implement. Although the basic drawback of Median Filtering is blurring the image in process, it could preserve the edges while suppressing the noise as well [3, 4, and 5]. Specifically, this filter supplants a pixel by the median of all pixels in the sliding window [5].

$$\hat{f}(x, y) = \underset{(x,\, t)\in S_{xy}}{median}\{g(s, t)\} \tag{1}$$

- Adaptive Median filter: Since Median Filter in the high noise level will smear some details, the Adaptive Median Filter has been proposed as one of the remedies for such drawback. This filter supplants the possible noisy pixels using the median filter or its variants, while doesn't change the other pixels value and also not care about local features like the probable presence of edges [6].

- Mean filter: Mean filters have the simpler structure relative to Median filters. It replaces the value of every pixel in an image with the mean (`average') value of its neighbours[7].The behaviour of this filter in presence of signal dependent noises is well [1]. Mean filter is usually used to suppress the small details in an image and also bridge the small gaps exist in the lines or curves [7]. The mean filter is defined as the following.

$$g(i, j) = \frac{1}{M \times N} \sum f(m, n) \tag{2}$$
$$m = 1,2...M, \quad n = 1,2...N.$$

where S is the neighborhood defined by the filter mask of the point $f(i, j)$, centered at point $f(i, j)$.

- Gaussian smoothing filter: Gaussian filter is a particular filter known for blurring and suppressing the noise [8]. This filter is a 2-D convolution operator with the weights selected pursuant to the shape of Gaussian function [9].The function is defined as the following [9].

$$g(x, y) = \frac{1}{M} \sum f(x, y) \exp\left[-((x-i)^2 + (y-j)^2)/2\sigma^2\right] \quad (i, j) \in S \tag{3}$$

Where S is every pixel set in the neighbourhood.
And,

$$M = \sum \exp\left[-((x-i)^2 + (y-j)^2)/2\sigma^2\right] \tag{4}$$

The equation defines the set of pixels and corresponding weights of S.

Adaptive Wiener filter: Adaptive Wiener filter is a developed statistical approach of Wiener filter to filter out the noises. The wiener filter is applied as a fixed filter throughout the image whereas Adaptive Wiener filter is based on the idea that the image characteristic change significantly from region to region. Therefore, Adaptive Wiener filter produce good edge sharpness and reduce blurring as well [10].

2.2. Noises

The Noises are reviewing in the following:

- Gaussian noise

Guassian noise is a kind of noise which influences all the pixel values. The random noise value at each pixel of noisy image is gained through the Guassian probability density function. The density function of this noise is defined as the following [11].

$$F(g) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-(g-m)^2/2\sigma^2} \quad (5)$$

Where g is a grey level, m is the average of the function and σ is the standard deviation of the noise.

- Salt & Pepper noise

Salt & Pepper noise contains black and white spots in an image. This noise is usually formed by the errors in data transmission and image sensor. It is figured out from different experimental researches that most of camera's images results in discrete pulses; salt and pepper noise and zero mean the Gaussian noise [9].

- Poisson noise

Poisson noise (Shot noise) is a kind of electronic noise which arised along the paucity of photons. In other words, it happens when the confined number of particles which carry energy is sufficiently narrow to ascend the detectable statistical fluctuations in a measurement [12].

- Speckle noise

Speckle noise as a multiplicative noise is caused by coherent processing of backscattered signals from multiple distributed objects. It is nearly arisen in different imaging systems like laser, acoustics and SAR (Synthetic Aperture Radar) imagery. Speckle noise enriches the mean grey level of a local area [12, 2]. This noise follows a gamma distribution as:

$$F(g) = \frac{g^{\alpha-1}}{(\alpha-1)!a^{\alpha}} e^{-\frac{x}{\alpha}} \quad (6)$$

Where $a^2\alpha$ is the variance and g is the grey level.

3. Simulation Results

The following figures represent the sample of Skin cancer images after simulating the Gaussian, Salt & Pepper , Speckle and Poisson noise, and de-noising the results using Median filter, Adaptive Median filter, Mean filter, Adaptive Mean filter, Gaussian smoothing filter and Wiener filter. The Simulation is run by MATLAB 7.12.0 (R2011a).

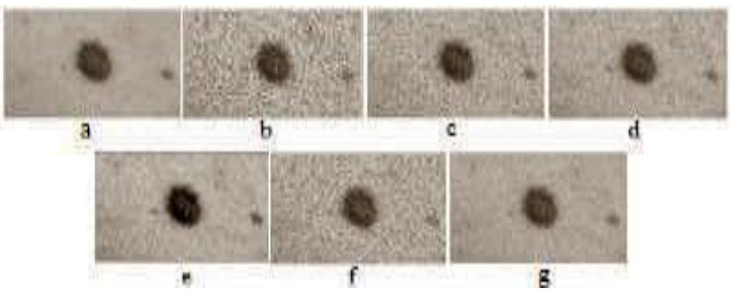

Fig. 2. a) Original image b) Simulated Speckle noise and de-noising by c) Gaussian Filter d) Median Filter e) Mean Filter f) Adaptive Median Filter g) Adaptive Wiener

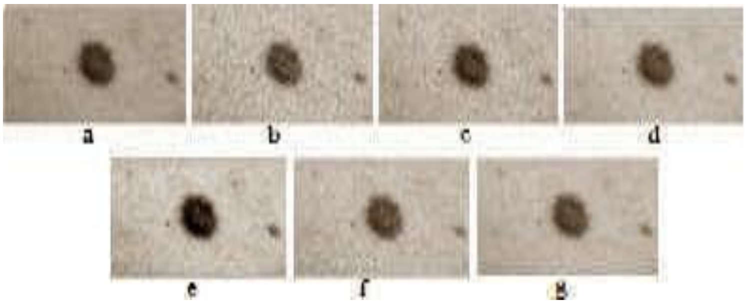

Fig. 3. a) Original image b) Simulated Gaussian noise and de-noising by c) Gaussian Filter d) Median Filter e) Mean Filter f) Adaptive Median Filter g) Adaptive Wiener

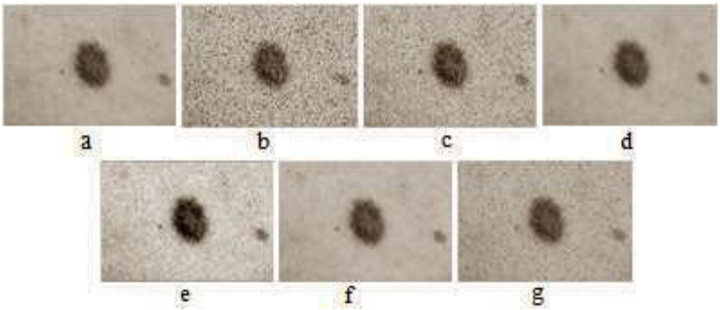

Fig. 4. a) Original image b) Simulated Salt & Pepper noise and de-noising by c) Gaussian Filter d) Median Filter e) Mean Filter f) Adaptive Median Filter g) Adaptive Wiener

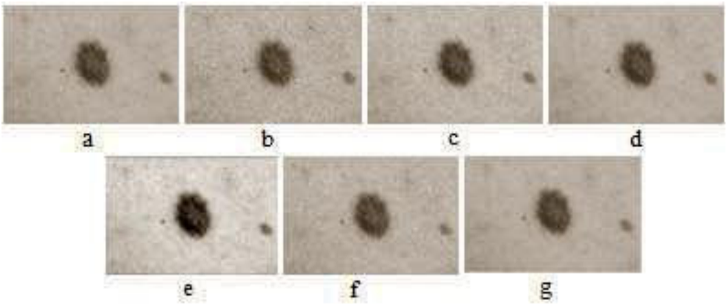

Fig. 5. a) Original image b) Simulated Poison noise and de-noising by c) Gaussian Filter d) Median Filter e) Mean Filter f) Adaptive Median Filter g) Adaptive Wiener

The comparison of images to achieve the most effective filter on different noises in different densities has been evaluated by peak signal-to-noise ratio (PSNR) which is the well-known index to compare the original and de-noised image. Mostly, the higher PSNR conduct a higher quality and less noisy image [5, 13]. The following table shows the PSNRs for sample Skin cancer image which has been simulated by Gaussian, Salt & Pepper , Speckle and Poisson noise, and then de-noised using Median filter, Adaptive Median filter, Mean filter, Adaptive Mean filter, Gaussian smoothing filter and Wiener filter to compare the performance for removing the noise and choosing the most effective filter. Table 1 has been classified according to 10% - 80% densities.

Table 1.Comparison of PSNR for a skin cancer image after simulating different noises and de-noising by filters in different densities

Density	10 %				20 %				30 %			
Noise / Filters	Speckle	Gussian	Salt & Pepper	Poison	Speckle	Gussian	Salt & Pepper	Poison	Speckle	Gussian	Salt & Pepper	Poison
Gussian	+30.72	+30.64	+38.59	+32.83	+29.38	+31.54	+36.83	+32.83	+28.87	+32.53	+35.53	+32.83
Median	+32.71	+34.20	+34.72	+33.99	+31.58	+35.97	+34.72	+33.99	+30.90	+37.79	+34.72	+33.99
Mean	+33.75	+34.65	+33.72	+34.07	+33.08	+36.34	+32.93	+34.07	+32.55	+37.84	+32.30	+34.07
Adaptive Median	+29.94	+30.33	+40.98	+32.10	+29.00	+31.14	+40.96	+32.10	+28.60	+32.00	+40.94	+32.10
Adaptive Wiener	+34.24	+34.97	+35.67	+34.71	+33.35	+36.90	+35.49	+34.71	+32.59	+38.86	+34.97	+34.71

Density	40 %				50 %				60 %			
Noise / Filters	Speckle	Gussian	Salt & Pepper	Poison	Speckle	Gussian	Salt & Pepper	Poison	Speckle	Gussian	Salt & Pepper	Poison
Gussian	+28.58	+33.59	+34.55	+32.83	+28.40	+34.73	+33.80	+32.83	+28.26	+35.94	+33.14	+32.83
Median	+30.43	+39.60	+34.71	+33.99	+30.10	+41.36	+34.71	+33.99	+29.84	+43.03	+34.70	+33.99
Mean	+32.12	+39.11	+31.74	+34.07	+31.75	+40.12	+31.30	+34.07	+31.41	+40.89	+30.82	+34.07
Adaptive Median	+28.37	+32.92	+40. 94	+32.10	+28.22	+33.59	+40.93	+32.10	+28.10	+34.93	+40.86	+32.10
Adaptive Wiener	+31.99	+40.78	+34.20	+34.71	+31.51	+42.61	+33.43	+34.71	+31.12	+44.33	+32.67	+34.71

Density	70 %				80 %			
Noise / Filters	Speckle	Gussian	Salt & Pepper	Poison	Speckle	Gussian	Salt & Pepper	Poison
Gussian	+28.16	+37.23	+32.61	+32.83	+28.07	+38.60	+32.15	+32.83
Median	+29.63	+44.62	+34.69	+33.99	+29.47	+46.12	+34.68	+33.99
Mean	+31.10	+41.47	+30.44	+34.07	+30.80	+41.94	+30.09	+34.07
Adaptive Median	+28.00	+36.00	+40.81	+32.10	+27.92	+37.14	+40.76	+32.10
Adaptive Wiener	+30.75	+45.92	+32.13	+34.71	+30.48	+47.38	+31.68	+34.71

After analysing Table 1, the most effective filters for removing different types of noises with densities of 10% - 80% have been summarized as Table 2.

Table 2. The most effective Filters on different noises with densities between 10% - 80%

Noise / Density	Speckle	Gussian	Salt & Pepper	Poison
10 % - 30 %	Adaptive Wiener	Adaptive Wiener	Adaptive Median	Adaptive Wiener
40 % - 80 %	Mean	Adaptive Wiener	Adaptive Median	Adaptive Wiener

According to table 2, Adaptive Wiener filter has the best performance in different intensities of Gaussian, Poison, and lower intensities of Speckle noise. In Speckle, when the intensities of noise increased more than 40%, Mean Filter performs the best. In all densities of salt & pepper noise, the Adaptive Median is the best candidate.

4. Conclusion and Future Work

So far in this paper, we discussed five different approaches of filtering and four kinds of noises (Speckle, Gaussian, Poisson and Salt & Pepper) which are added to the skin cancer image with different intensities of 10% - 80% for the application in medical field. The degraded image is de-noised by all filters. The purpose is performing the comparison by calculating PSNR to figure out the behaviour of filters in the presence of different kinds of noise. The results shows the best performance of Adaptive wiener in different intensities of Gaussian, Poisson and low intensities of Speckle, Adaptive

Median Filter in Salt & Pepper noise and Mean Filter in high intensities of Speckle.

Since the purpose of this paper is to give the idea to researchers for selecting the best techniques in the preprocessing of their skin cancer detection system to provide a desirable result, in future work we would like to perform further comparison in different wavelet-based techniques on skin cancer images and evaluate the efficiency using the results in further stages of detection system.

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