Filtering Techniques To Reduce Speckle Noise And Image Quality Enhancement Methods On Porous Silicon Images Layers

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ABSTRACT:
Recently, many studies have examined filters for reducing or removing speckle noise, which is inherent to different images types such as Porous Silicon (PS) images, in order to ameliorate the metrological evaluation of their applications. In the case of digital images, noise can produce difficulties in the diagnosis of images details, such as edges and limits, should be preserved. Most algorithms can reduce or remove speckle noise, but they do not consider the conservation of these details. This paper describes in detail, the different techniques that focus mainly on the smoothing or elimination of speckle noise in images, as the aim of this study is to achieve the improvement of this smoothing and elimination, which is directly related to different processes (such as the detection of interest regions). Furthermore, the description of these techniques facilitates the operations of evaluations and research with a more specific scope. This study initially covers the definition and modeling of speckle noise. Then we elaborated in detail the different types of filters used in this study, finally, five statistical parameters such as Root Mean Square Error (RMSE), Mean Square Error (MSE), Structural Similarity Index (SSIM), Peak Signal to Noise Ratio (PSNR), Signal to Noise Ratio (SNR) are calculated, compared and the results are tabulated, common in filter evaluation processes. Trough the calculation of the statistical parameters, we can classify the filters in terms of perceptual quality by providing greater certainty.

KEYWORDS: Porous Silicon, Speckle Noise, Speckle Filtering, Statistical Measures.

1. INTRODUCTION

The processing of porous silicon images is of the order of µm and nm obtained by the Scanning Electron Microscope (SEM) which depends on providing images about the composition of the sample and the surface topography, by using a focused beam of electrons to scan the surface, this operation pass through the interaction between the atoms of this sample. This operation requires the use of well specified techniques to calculate, process, measure and select the parameters and properties of the image such as diameters and depths of holes created by the beam of electrons, because each variation can create a bad result, and as the use of characterization devices use a digital system to process SEM images, so it will pass through several operations , which affects the quality of the image that will be infected by speckle noise and can make it difficult to obtain a good diagnosis.

Digital Image processing plays an important role, in areas of technology and research such as digital processing of photographic images, radar or satellite transmission, as well as medical field such as computer tomography and magnetic resonance imaging [1]. During image data acquisition and transmission process, images are usually affected by speckle noise [2]. The noise classified is mathematically on two models, additive and Multiplicative noise. The first has a systematic nature and can be easily modeled and thus

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removed [3-4]. Whereas, the latter is image dependent as it is multiplied by pixel density and appears in all coherent digital imaging systems, and is difficult to model and remove [5]. The aim of the noise remove techniques is to remove or reduce speckle noise and keep the important characteristics of the images [2] without destroying useful diagnostic information. As found in literature, many published works were limited only on two images types such as radar or satellite images [2-3], [7-8] and medical images [3,6,9], although there are other images types that are threatened by speckle noise such photographic images displayed on screens and assisted by digital processing equipment or computers, for this reason, we have chosen to study these types of images. As are often known, several types of filters are used in images treatment. Generally, these filters are classified into two parts, adaptive filters and non-adaptive filters. Among the adaptive filters we have chosen six types which are most used in the field of image filtering. In the present work, we have been applying the previous chosen filter types to reduce the noise and select the best filter for corresponding images.

1.1. Additive Noise

Additive Noise (AN) model is generally found in operation of acquiring images from digital devices [10]. This model type is currently used by the most of literatures to process images formation. Additive noise is independent of the pixel value in the original image [1]. Then it is given by the equation

$$f'[m,n] = f[m,n] + \eta[m,n] \tag{1}$$

Where, $f[m,n]$, $f'[m,n]$ and $\eta[m,n]$ indicate the original image, the noise assimilate version and the noise function, respectively, which the last one returns values coming from an arbitrary distribution, it is typically symmetric about zero.

1.2. Speckle Noise

There are different types of noise. Multiplicative and additive noise are beside each other. This noise type affects the image quality, which may degrade while images acquisition, transmission, and storage [11]. Speckle noise plays an important role in data extraction from images [12]. The noise of the original record equipment, external perturbation, according to the hypothesis imaging system is a linear translation invariance system. Objects movement and the flaws of the imaging system also cause the image noise. [11]. This system is defined by the multiplicative noise model, its mathematical expression is given by:

$$f'[m,n] = f[m,n] + \eta[m,n] f[m,n] \tag{2}$$

$$f'[m,n] = f[m,n] + [1 + \eta[m,n]] \tag{3}$$

2. SOURCES OF NOISE IN IMAGES

Several sources of noise affect the quality of images during acquisition and transmission process. Generally, noise is measured by the ratio of the corrupted image pixel. Depending on how the image has been created, among the causes that lead to increase noise in the original image, we find:

1- If the image is scanned from a photograph made on film, the film grain may be a source of noise which also be the result of damage to the film, or be introduced by the scanner or the imaging system itself.

2- The capture and saving of the digital image format realized by the data collection mechanism may introduce noise.

3- Electronic acquisition or transmission process of image data can also introduce noise [13-14].

4- The wrong penetration of light is emitted from the source to the device lens due to the wrong opening of the device sensor, then arises noise into the image. Light levels and sensor temperature are major causes in producing a noise.

5- The parameter of dynamic range used in mapping a 3D view in the image planes. Decreasing or increasing the range can introduce noise, the first by the more intensity which collects on the pixels, and the second by the light intensity which is scattered into a wide region, which also makes the picture noisy [14].

3. DENOISING

Denoising is the process of reducing images noise [15]. It is a technique that makes the image more appropriate for the next steps of the image processing after removing the undesirable information [5]. Conceptually, and regardless of the image type being processed, the noise reduction techniques are very similar, while it is greatly depending on the signal type, However, a prior knowledge of signal characteristics is required, which needs the implementation of noise reduction techniques. Where an image was infected with noise, it needs to be enhanced before it can be used. So, the main role of denoising techniques is not only to reduce noise, but also to preserve the characteristics of images such as edges [16]. Image denoising is often used in several domains like radar, satellite or medical processing applications. In photography fields, noise is made up of lots of small points that are created, in astronomy, there are physrestoreical requirements for high-quality imaging to get good results and appropriate image analysis, because the resolution limitations are intense. For this type of application, it is necessary to develop a model after the knowledge of the degradation processes, then we apply the inverse process to restore the information of the original image.

4. PROPOSED METHODOLOGY

Our work is based on the use of several techniques for the reduction speckle noise of PS images with different views (Top view and side view). Several filters are used for speckle reduction. According to the image type, there is a specific filter well adapted to remove the noise, some filters are best adapted for some specific class of images. So, some filters are best adapted for photographic images, others are best adapted for medical images, others are best adapted for SAR images and so on. The proposed work is a comparative study on the performance of the several filters such as Frost Filter, Lee Filter, Weiner Filter, Kuan Filter, SRAD Filter and Median Filter in reduce or remove the speckle noise from the different input images. The statistical parameters such as SNR, PSNR, SSIM, MSE, RMSE are calculated and compared for the output images obtained from the filters to assess the quality of the images used in our work. The images corresponding to the best value of the statistical parameters are presented and the results are discussed to choose the best filter for the image type used, and allows us to make a good diagnosis and extract the best precise measurements of the PS thin layers such as the diameters and depths of the holes.

5. METHODS FOR SPECKLE FILTERING

To denoising images infected by speckle noise, there are various methods available, includes filtering techniques like Frost Filter, Lee Filter, Weiner Filter, Kuan Filter, SRAD Filter and Median Filter.

5.1. Median Filter

Median filter is one of the known tools employed to reduce the level of impulse noise from infected images [17][18]. It can be considered as a spatial nonlinear filter; its role is to remove spike or pulse noise by replacing the middle pixel value in the window with the median value of other pixels from neighbors [19]. Furthermore, the median filter can preserve the details of the image, so it is a very effective filter because it is based on values that converge to the typical values of the neighborhood [20]. This filter can be used as a linear filter, it is applied to successive image windows. But the method used does not use a weighted sum. The pixels of the window are sorted in ascending order, which the pixels values in the middle of the window are selected as the new values for a particular pixel. The advantage of this filter is preserving the edges [19]. Whereas, disadvantage of this filter, it needs a long time for calculate of the median value for sorting specific number of N pixels.

5.2. Lee Filter

Lee Filter is an adaptive filter which can smooth away the speckle noise in flat regions and preserve the fine details such as textures and lines. This filter can change the characteristics of pixels according to the local statistics in the neighborhood of the current pixels [21]. It is developed to reduce speckle noise while retaining point features and edges in photographic imagery [22]. The Lee filter is used to reduce the multiplicative noise [23], this model is a linear model in the first time. Then the minimum mean square error criterion is applied to the linear model [24]. The resulting grey level value R for the smoothed pixel can be calculated as:

$$R = I_c * W + I_m * (1 - W) \tag{4}$$

Where $W = 1 - \frac{C_u^2}{C_i^2}, C_u = Sqrt\left(1/N_{look}\right), C_i = S/I_m$, I_c is the pixel situated in the center of the filter window. I_m = is the intensity value within window, S = standard deviation SD of intensity within window, the C_u function defined above is the coefficient of variation of the estimated noise. W is a weighting function, C_i is the coefficient of image variation.

5.3. Frost Filter

It was developed in 1982 by Frost, it is used to remove or reduce the speckle noise from different images types, this filter is considered as a linear convolutional filter [21]. Frost filtering is an adaptive approach based on local statistic about the selected pixel. It works as a mean filter in homogenous regions, and at edges, the filtering process is prevented completely. Typically, noise reduction is widely realized by smoothing in homogeneous region, and lesser smoothing in edges and the regions with high contrast pixels. Thus, the estimation of speckled pixel value is defined by the weighting coefficient, which decreases from the center of filter when high contrast regions are filtered [25]. The filter output is determined by

$$\hat{x}_s = \Sigma_{p \in \eta} k_p x_p \tag{5}$$

Where, x_p is noisy pixel of interest in the window k_p is given by

$$k_p = e^{(-KA_s^2 dis_{s,p})} / \Sigma_{p \in \eta} e^{(-KA_s^2 dis_{s,p})} \tag{6}$$

Where, K, coefficient of damping, is selected so that $KA_s^2 \to 0$ in homogeneous regions and gives a mean filter output and $KA_s^2 \to \infty$ (so large) at edges and gives lesser or no filtering or smoothing.

$$A_s^2 = (1/|\eta_s|)\Sigma_{p\in\eta}(x_p - \bar{x}_s)^2 / (x_p - \bar{x}_s)^2 \quad (7)$$

Where, $\bar{x}_s$ is the intensity mean value inside the filter window η_s

$$dis_{s,p} = \sqrt{(i-i_p)^2 + (j-j_p)^2} \quad (8)$$

(i_p, j_p) is the grid coordinates of pixels and (i_p, j_p) is the grid coordinates of pixel p.

5.4. Kuan Filter

It was developed in 1987 by Kuan, Kurlander and Nathan [21]. Kuan effects spatial filtering on each pixel of image by the use the grey level values R in a square window around each selected pixel. The filter dimensions must be odd-odd and take confined values from 3x3 to 11x11 pixels. All pixels of window must be filtered. To reproduce sufficient data, the pixels situated near image edges must be filtered. The value grey level R for the smoothed pixel is given by[24]:

$$R = C_p * W + I * (1-W) \quad (9)$$

Where,

$C_u = 1/N_{look}, C_i = Var/I, W = (1 - C_u / C_i)/(1 + C_u)$,

N_{look} = Number of Looks, C_p = central pixel in filter window, Var = Variance in filter window, i = Level of mean grey within the filter window.

5.5. Wiener Filter

The role of wiener filter is to reduce the MSE as much as possible between the original and filtered image [26]. Because the pixels intensities in the weld zone follow a Gaussian distribution, this filter is self-adaptive for local image variance. When the variance is large, it performs low smoothing. Although, when the variance is small, it performs more smoothing. So, this filter is used for radiographic images filtering [27].

5.6. SRAD filter

SRAD filter use the coefficient of variation in adaptive filtering [28], it is characterized by the coefficient of variation instantaneous, which can be considered as detector of edges in corrupted images. It reduces speckle by modifying the image by the partial differential equation (PDE) solution and at the same time improves the edges. This filter is used for noisy images without the application of logarithmic compression. In the case of diffusion filtering, the diffusion force and direction are checked by a function called edge detection function. the values presented by this function are different, it produces high values at edges and presents low values in homogeneous areas [29].

6. ESTIMATION OF STATISTICAL PARAMETERS

After the filtering step and before choosing the best filter, we must evaluate the performance of the proposed filters for speckle noise reduction and to evaluate their comparative rerformance, for this reason, the parameters used are PSNR, SNR , RMSE, MSE and Structural Similarity Index (SSIM).

6.1. Estimation of SNR

SNR is a measurement of distortion. Especially in homogeneous regions, it indicates the effect of noise. This factor can be calculated as:

$$SNR = 10\log_{10}\left(\frac{\sigma_g^2}{\sigma_e^2}\right) \quad (10)$$

Where, σ_g^2 is the noise variance of original image and σ_e^2 is the variance of error (between the filtred image and original image). The higher of SNR value, means a good image quality [1].

6.2. Estimation of PSNR

PSNR is the ratio between the maximum possible power of signal and the corrupting noise power, which effects the reliability and quality of original signal. PSNR is calculated as

$$PSNR = 10\log_{10}\left(\frac{MAX^2}{MSE}\right) \quad (11)$$

Where, MAX is the image maximum pixel value and MSE is Mean Square Error [30].

6.3. Estimation of MSE

The MSE is the cumulative mean square error between the original and filters image, it can be calculated by [31]:

$$MSE = \sum_0^{m-1}\sum_0^{n-1}\left\| f(i,j) - g(i,j)\right\|^2 \quad (12)$$

6.4. Estimation of RMSE

RMSE is used to measure the accuracy frequently and the difference between values actually observed and the values predicted by an estimator or a model [32]. A lower value for RMSE means low error, which leads to a high PSNR value [33]. Its formula is given by

$$RMSE = \sqrt{MSE} \tag{13}$$

6.5. Estimation of SSIM

The index is a reference to measure the image quality [34], it is used to estimate the similarity between two images. To perceive the image distortion, the measurement of SSIM should present a good approximation and compared to the reference image. This parameter is defined as follows:

$$SSIM = \frac{\left(2\mu_x\mu_y + C_1\right)\left(2\sigma_{xy} + C_2\right)}{\left(\mu_x^2 + \mu_y^2 + C_1\right)\left(\sigma_x^2 + \sigma_y^2 + C_2\right)} \tag{14}$$

Where, μ_x is the average of x, μ_y is the average of y, σ_x^2 is the variance of x, σ_y^2 is the variance of y, σ_{xy} is the covariance of x and y, $C_1 = \left(k_1 L\right)^2$, $C_2 = \left(k_2 L\right)^2$ two variables are used to stabilize the division with weak denominator, L is the pixel values dynamic range (generally this is $2^{\text{bit per pixel}}$ -1), k_1=0.01 and k_2=0.03 [35].

The resulting SSIM index is a value between -1 and 1, the 1 value is not available and not accessible only in the case of better image quality or two identical images data [36].

7. ALGORITHM FOR FILTER SELECTION

As depicted in Fig. 1, we have developed an organigram to explain the different steps followed to choose the best filter corresponding to the specific image type. At the first, the input images are corrupted with uniformly distributed multiplicative noise. With three different values of standard deviation (σ) of the noise, two images are produced. Noisy images are filtered by using six filters such as Frost Filter, Lee Filter, Weiner Filter, Kuan Filter, SRAD Filter and Median Filter. After the filtering, the output images are saved for evaluation of statistical measures. Statistical parameters such as PSNR ,SNR, RMSE, MSE and SSIM are calculated for the filtered images obtained from each filter and we obtain six sets of statistical parameters, each set corresponding to a specific filter. Finally, filtered image and statistical parameters corresponding to the best result obtained are given in the output after the comparison of the six results for each image.

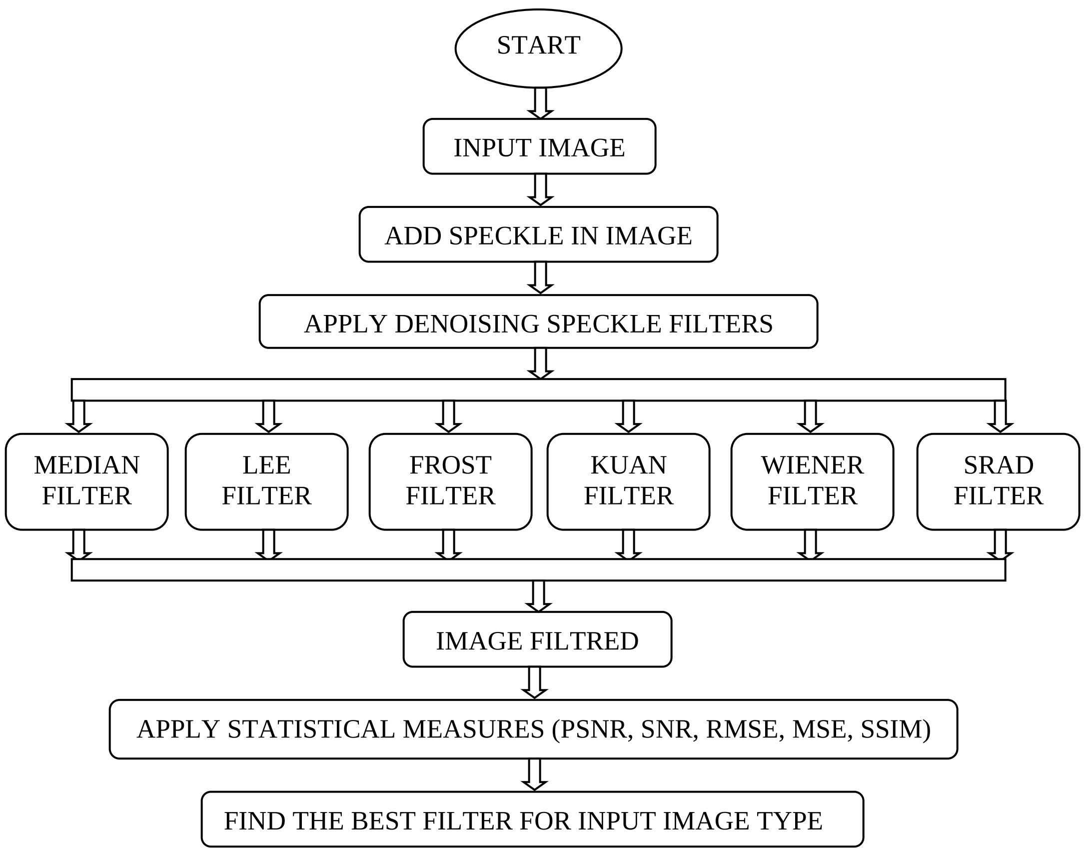


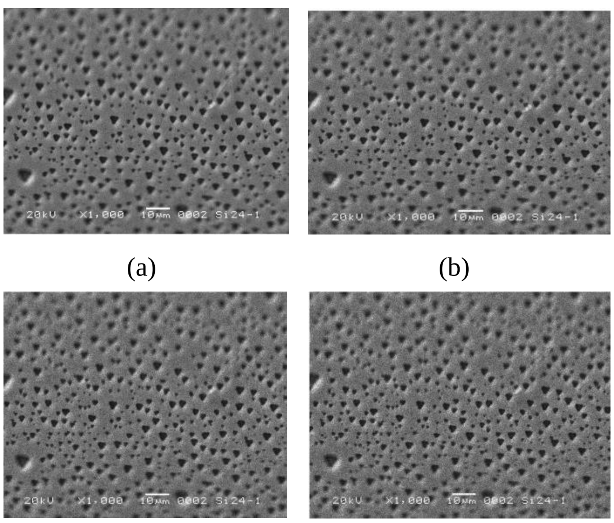
Fig. 1. Proposed Algorithm for Speckle noise reduction.

8. EXPERIMENTAL RESULTS

In this section we discussed the experimental results. The application of speckle noise reduction filters allows to obtain results of two different images. Selected images are PS images (top view TP and side view SV), these images were filtered using Frost Filter, Lee Filter, Weiner Filter, Kuan Filter, SRAD Filter and Median Filter, by using 3x3 window size.

To compare the efficiency of each filter, performance measurements of the reduction filters are performed for each speckled image. In the first, we have introduced three values of variances (0.01, 0.02 and 0.03) for each image type as shown in Figs. (2 and 12), then, six filters type are applied to study their effectiveness and extract the statistical parameters. The different results obtained are illustrated in the following tables and figures. In Figs. (6, 16), (7, 17), (8, 18), (9, 19), (10, 20), and (11, 21), speckle noise reduction using Lee, Frost, Kuan, Wiener, Median and SRAD filter respectively are shown. Moreover, the statistical parameters deduced from the precedent results are reported in Tables (1-6), this obtained results are traced in the schematized graphs Figs. (3-5, 13-15).

8.1 Top view image



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

Fig. 2. (a) Original Image (b) Noisy image with SD 0.01, (c) Noisy image with SD 0.02, (d) Noisy image with SD 0.03.

Table 1. Results of TP image with standard deviation 0.01.

FILTER	SSIM	SNR	PSNR	MSE	RMSE
Lee	**0.916**	**23.358**	**31.650**	**44.811**	**6.6942**
Frost	0.459	14.196	16.489	1470.6	38.348
Kuan	0.541	14.505	17.661	1122.9	33.509
Wiener	**0.932**	**24.414**	**32.090**	**40.5**	**6.3640**
Median	0.894	21.761	27.487	116.87	10.811
SRAD	0.856	4.0694	20.109	639.11	25.280

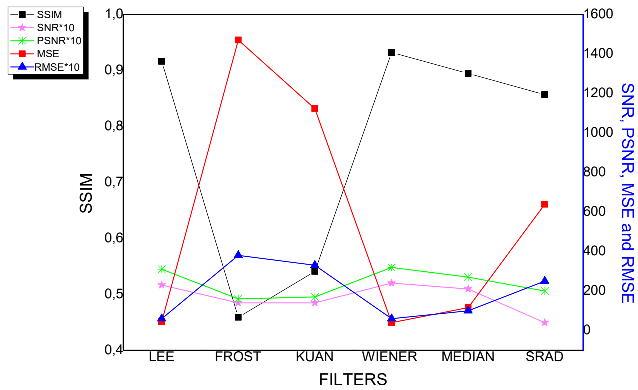


Fig. 3. Graph for TP image with standard deviation 0.01.

Table 2. Results of TP image with standard deviation 0.02.

FILTER	SSIM	SNR	PSNR	MSE	RMSE
Lee	**0.906**	**22.684**	**30.845**	**53.9389**	**7.3443**
Frost	0.453	14.179	16.462	1479.9	38.469
Kuan	0.535	14.494	17.620	1133.5	33.667
Wiener	**0.902**	**22.30**	**30.298**	**61.1788**	**7.8217**
Median	0.846	19.61	26.771	137.8152	11.7395
SRAD	0.850	4.095	19.75	693.069	26.326

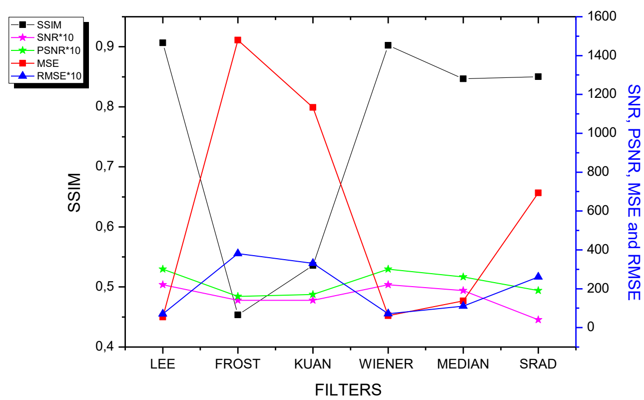


Fig. 4. Graph for TP image with standard deviation 0.02.

Table 3. Results of TP image with standard deviation 0.03.

FILTER	SSIM	SNR	PSNR	MSE	RMSE
Lee	**0.890**	**21.509**	**29.645**	**71.112**	**8.4328**
Frost	0.448	14.129	16.435	1489	38.588
Kuan	0.530	14.434	17.576	1145	33.838
Wiener	**0.874**	**20.818**	**29.001**	**82.476**	**9.0817**
Median	0.808	18.140	26.125	159.929	12.646
SRAD	0.842	4.284	19.983	657.895	25.649

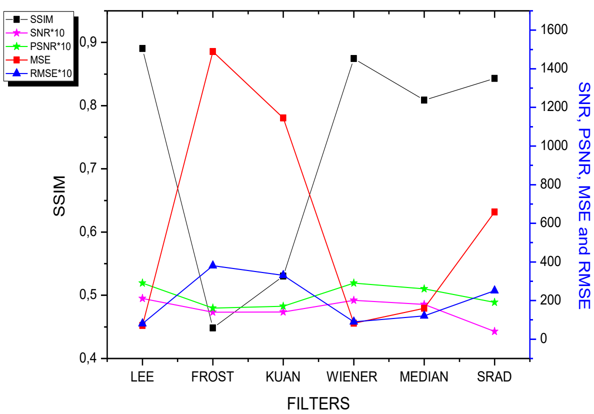
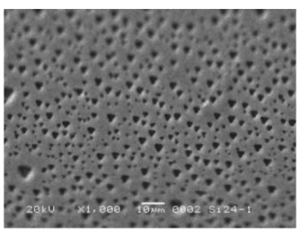
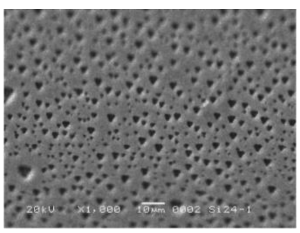


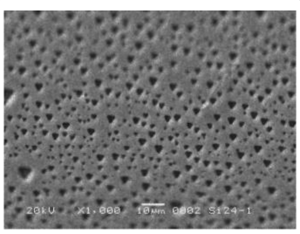
Fig. 5. Graph for TP image with standard deviation 0.03.



(a)

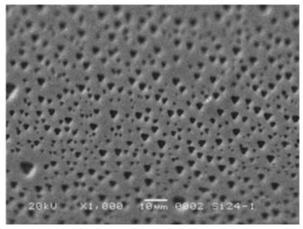


(b)

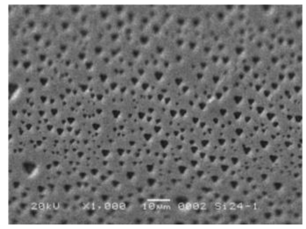


(c)

Fig. 6. Speckle noise reduction using Lee filter, (a) Denoised image for SD 0.01, (b) Denoised image for SD 0.02,(c) Denoised image for SD 0.03.



(a)



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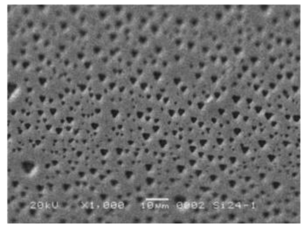
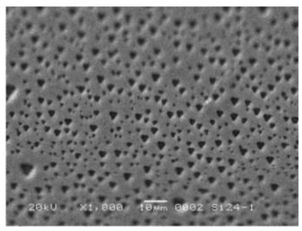
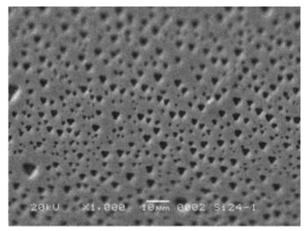


(c)

Fig. 7. Speckle noise reduction using Frost filter, (a) Denoised image for SD 0.01, (b) Denoised image for SD 0.02, (c) Denoised image for SD 0.03.



(a)



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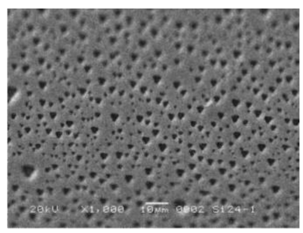
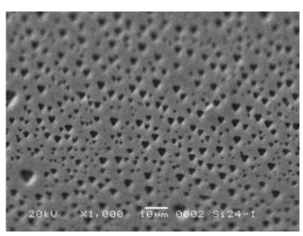
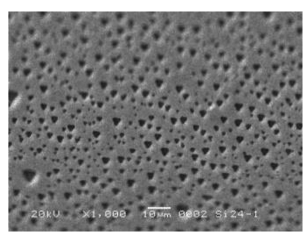


(c)

Fig. 8. Speckle noise reduction using Kuan filter, (a) Denoised image for SD 0.01, (b) Denoised image for SD 0.02, (c) Denoised image for SD 0.03.



(a)



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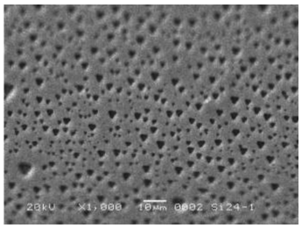
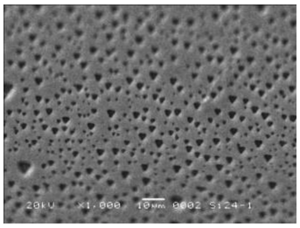
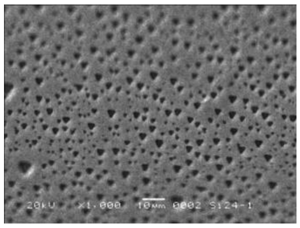


(c)

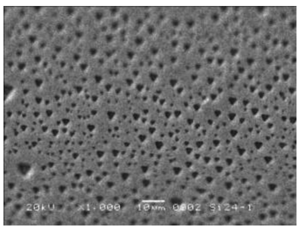
Fig. 9. Speckle noise reduction using Wiener filter, (a) Denoised image for SD 0.01, (b) Denoised image for SD 0.02, (c) Denoised image for SD 0.03.



(a)

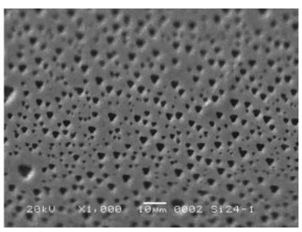


(b)

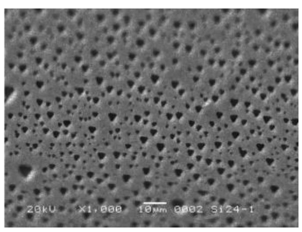


(c)

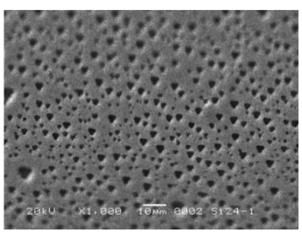
Fig. 10. Speckle noise reduction using Median filter, (a) Denoised image for SD 0.01, (b) Denoised image for SD 0.02, (c) Denoised image for SD 0.03.



(a)



(b)

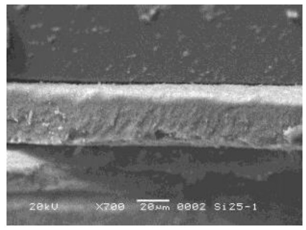


(c)

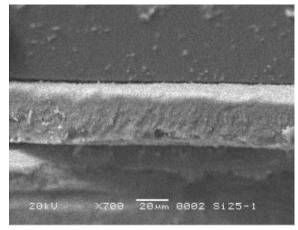
Fig. 11. Speckle noise reduction using SRAD filter, (a) Denoised image for SD 0.01, (b) Denoised image for SD 0.02, (c) Denoised image for SD 0.03.

By analyzing above results we can infer that Lee and Wiener give optimal results.

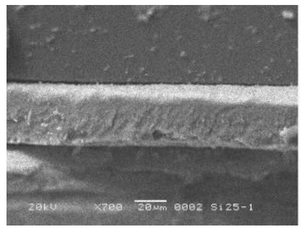
8.2 Side view image



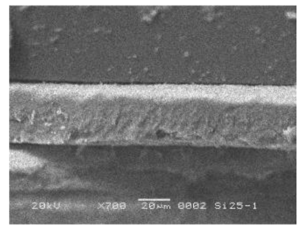
(a)



(b)



(c)



(d)

Fig. 12. (a) Original Image (b) Noisy image with SD 0.01, (c) Noisy image with SD 0.02, (d) Noisy image with SD 0.03.

Table 4. Results of SV image with standard deviation 0.01.

FILTER	SSIM	SNR	PSNR	MSE	RMSE
Lee	**0.938**	**20.155**	**30.257**	**61.763**	**7.858**
Frost	0.448	10.429	16.425	1492.6	38.633
Kuan	0.531	10.637	17.577	1144.8	33.834
Wiener	**0.949**	**20.880**	**30.630**	56.684	7.528
Median	0.925	18.817	26.775	137.685	11.733
SRAD	0.940	14.993	29.514	73.2803	8.560

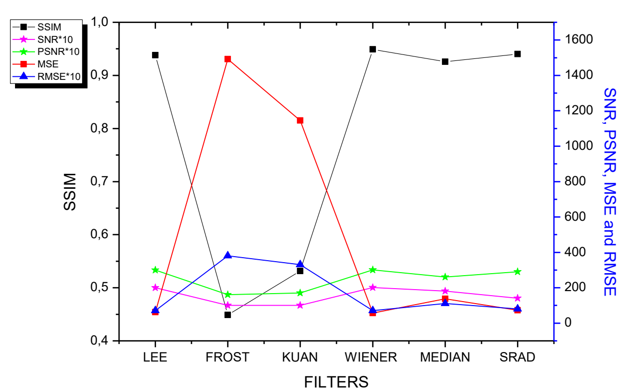


Fig. 13. Graph for SV image with standard deviation 0.01.

Table 5. Results of SV image with standard deviation 0.02.

FILTER	SSIM	SNR	PSNR	MSE	RMSE
Lee	**0.933**	**19.605**	**29.701**	**70.192**	**8.378**
Frost	0.444	10.438	16.416	1495.7	38.674
Kuan	0.526	10.641	17.560	1149.4	33.903
Wiener	**0.933**	**19.832**	**29.754**	**69.350**	**8.327**
Median	0.899	17.384	26.193	157.430	12.547
SRAD	0.930	13.706	28.140	100.564	10.028

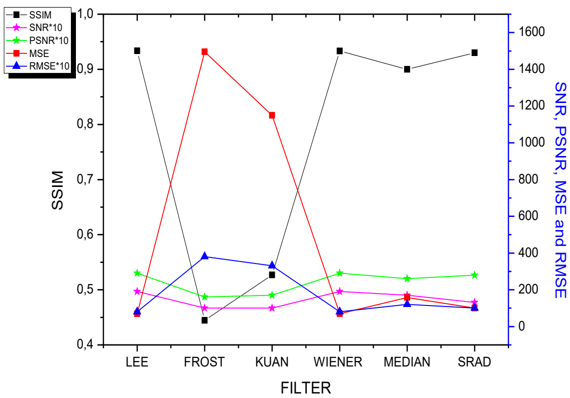


Fig. 14. Graph for SV image with standard deviation 0.02.

Table 6. Results of SV image with standard deviation 0.03.

FILTER	SSIM	SNR	PSNR	MSE	RMSE
Lee	**0.920**	**18.216**	**28.497**	**92.624**	**9.624**
Frost	0.442	10.432	16.418	1494.8	38.662
Kuan	0.524	10.638	17.566	1147.6	33.876
Wiener	**0.917**	**18.948**	**29.002**	**82.464**	**9.081**
Median	0.876	16.305	25.640	178.812	13.372
SRAD	0.908	13.429	26.828	136.035	11.663

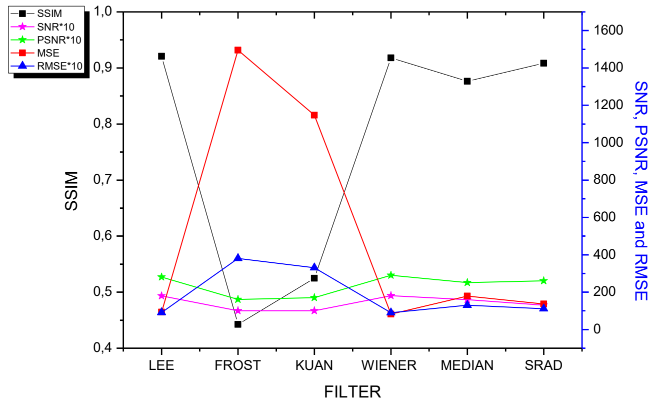
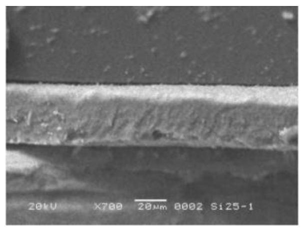
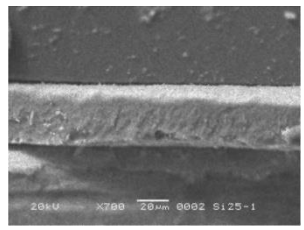


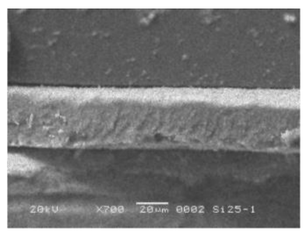
Fig. 15. Graph for SV image with standard deviation 0.03.



(a)

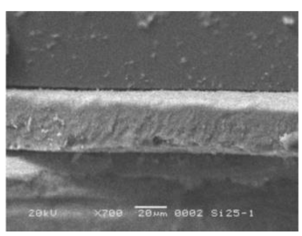


(b)

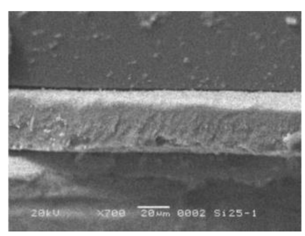


(c)

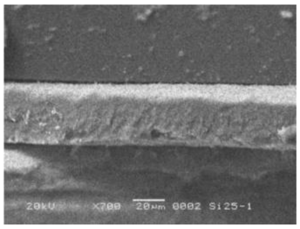
Fig. 16. Speckle noise reduction using Lee filter, (a) Denoised image for SD 0.01, (b) Denoised image for SD 0.02, (c) Denoised image for SD 0.03.



(a)

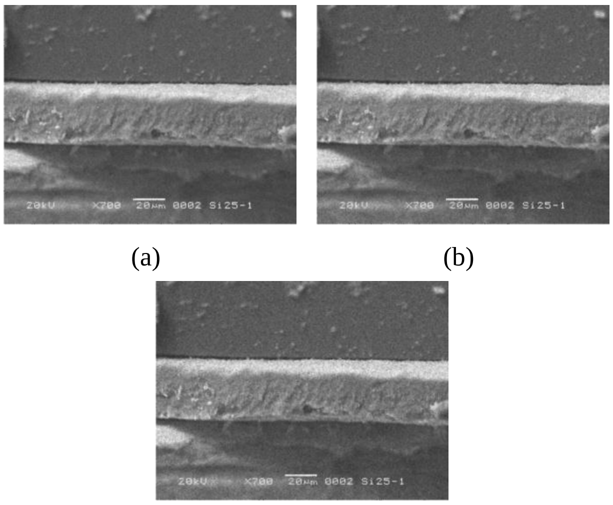


(b)



(c)

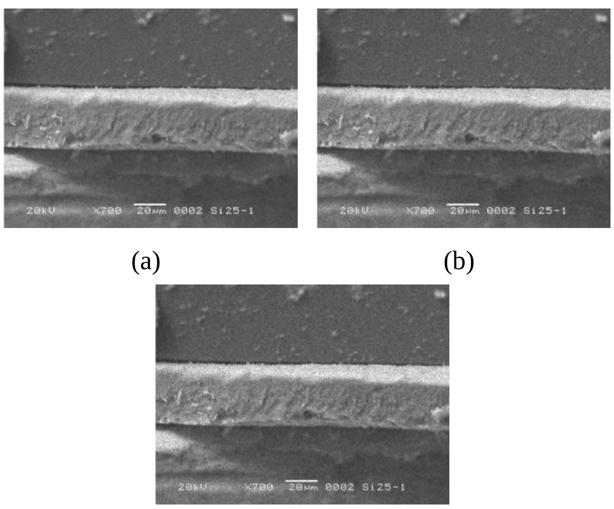
Fig. 17. Speckle noise reduction using Frost filter, (a) Denoised image for SD 0.01, (b) Denoised image for SD 0.02, (c) Denoised image for SD 0.03.



(a) (b)

(c)

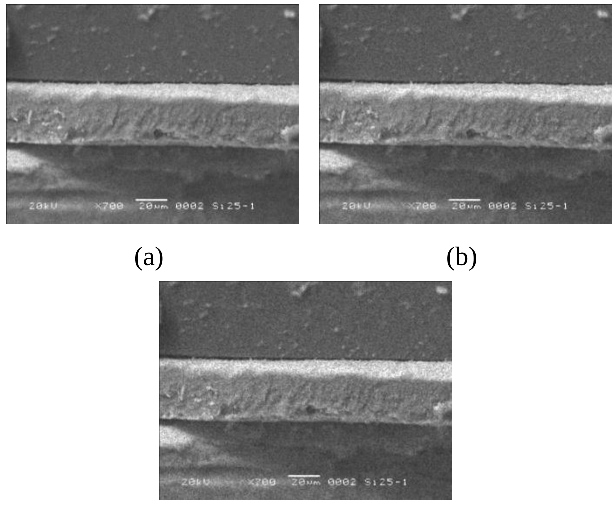
Fig. 18. Speckle noise reduction using Kuan filter, (a) Denoised image for SD 0.01, (b) Denoised image for SD 0.02, (c) Denoised image for SD 0.03.



(a) (b)

(c)

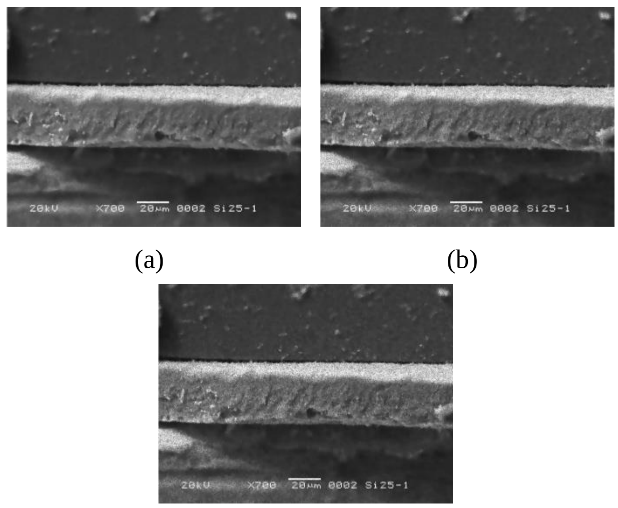
Fig. 19. Speckle noise reduction using Wiener filter, (a) Denoised image for SD 0.01, (b) Denoised image for SD 0.02, (c) Denoised image for SD 0.03.



(a) (b)

(c)

Fig. 20. Speckle noise reduction using Median filter, (a) Denoised image for SD 0.01, (b) Denoised image for SD 0.02, (c) Denoised image for SD 0.03.



(a) (b)

(c)

Fig. 21. Speckle noise reduction using SRAD filter, (a) Denoised image for SD 0.01, (b) Denoised image for SD 0.02, (c) Denoised image for SD 0.03.

By analyzing above results we can infer that Lee and Wiener Filter gives optimal results.

9. CONCLUSION

Six filters for three variance values are used to remove speckle noise and retain image features like edges and limits etc. Hence we proposed an algorithm that can allow automatically find which filter type must be used for each image and which gives optimal results through the different results produced by several techniques of filtering. The measurement of statistical parameters allows to evaluate the performance of the algorithm. According to the results obtained, we observed that the increase of standard deviation has a negative effect on the quality of images, whereas in most cases and for all types of filters and images, the values of SSIM, SNR and PSNR decrease, while, the values of MSE and RMSE increase, so the operation of comparison and the choice of the best filter is related to these statistical parameters. From the obtained tables, we have traced the compared graphs showing the appropriate filter corresponding to the images. The increase of the speckle noise variance has a negative effect on the image quality, as the noise increases and the filter performance decreases slightly. According to the results obtained from the six filters used, Lee and Wiener Filter gives best results for the PS images type. Then, the use of filtering allows us to determine the ideal constitutions of images for obtaining a good performance and improves the diagnostic level for these thin films.

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