

Denoising of Stego-images for different noise models

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Abstract:

Steganography plays an important role in secret communication systems, however the main drawbacks in Stego- images are presence of noise and degradation during acquisition or transmission. In this paper different noise models, including additive and multiplicative types, are studied. They include Gaussian noise, salt and pepper noise and speckle noise. The criterion of noise removal problem depends on noise type by which image is corrupting. Several types of linear and nonlinear filtering techniques are proposed and applied for noise removal. Experiments show that Mean Square Error (MSE), Peak Signal to Noise Ratio (PSNR) and Correlation (COR), are the most suitable assessment parameters.

Keywords:

Discrete Wavelet Transform, Stego-image, Noise Model, Average filter, median filter and Wiener filter.

I. INTRODUCTION:

In modern Steganography techniques there are different types of image Steganography: spatial domains, statistical analysis, transform domain, and hybrid domain. The Spatial domain directly embeds a secret message in pixels of an image intensity. The main advantage of this method is simple and fast, but it has less capability towards signal processing or noises. The mostly used known algorithm is the change in least significant bits (LSB), where the LSB of a pixel is returned by the message to be sent. The Transform domain changes image data into particular domain coefficients by mathematical tools. According to this domain the produced coefficients are embedded into other coefficients of that domain. The hybrid domain combines both the spatial domain as well as the transform domain to achieve greater security. In statistical analysis assessment parameters are to be used, e.g. Quality, visualization, correlation, distribution are applied [1, 2].

II. THE PROPOSED METHOD

A modified embedding weighting function is introduced to combine between a weighted DWT coefficient of the corresponding sub-bands of the cover image and secret message. The weighting embedding function is given by [3].

$$S(j, k) = \beta C(j, k) + \alpha M(j, k) \quad (1)$$

where

$$\beta + \alpha = 1 \quad (2)$$

α and β are two weighting intensity factors for the DWT of the Secret message (M), cover image (C) respectively, and (S) is the modified DWT coefficients of the stego-image[4]. When the Stego-image is transmitted through a communication channel, it corrupted by existence of noise such as Gaussian noise, Salt&pepper noise and Speckle noise. To reduce the effect of these different types of noise, without Loss or damage edge Details of Stego-image, is to use different filters whether Linear or nonlinear such as Average filter,

Wiener filter and Median filter. Figure (1) shows the block diagram of the noisy Stego-system. The DWT is to be applied to the cover image to generate LH, HL, HH and LL bands and the fuzzification is used to compress the secret message and applied the DWT then embed it to the cover image according to weighting embedding function. Then the IDWT is applied to perform Stego-image. So the weighting embedding function including noise will be given by:

$$S(j, k) = \beta C(j, k) + \alpha M(j, k) + N(j, k) \quad (3)$$

where (N) is noise model

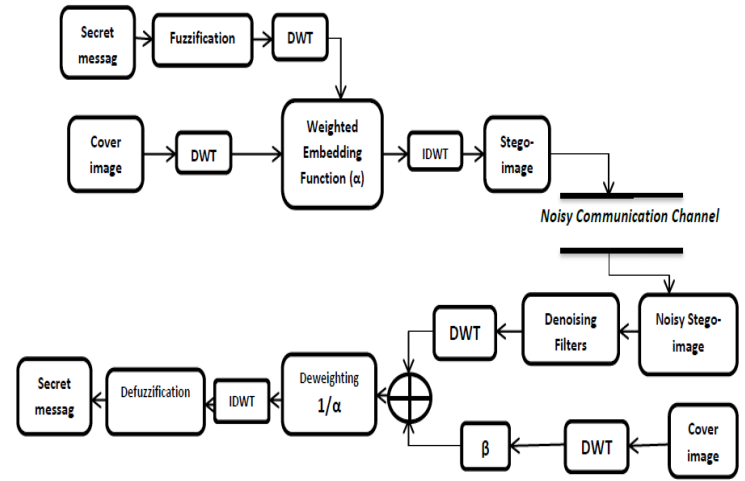


Fig. (1): The Block diagram of the noisy Stego-system.

Figure (2) show the stego-image before entering in the noisy communication channel, Lena is used as a cover image and (House or Locomotive) as secret message for different values of ESF ($\alpha=0.1 - \alpha=0.8$).

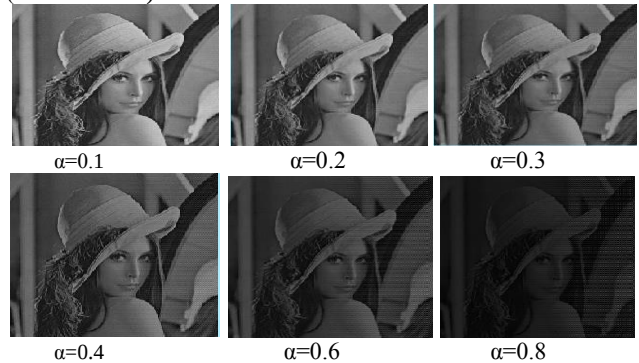


Fig. (2): The stego-image with different values of ESF.

Figure (3) shows the stego-image after transmission through the noisy communication channel with different types of noise, such as Gaussian noise, Salt&pepper noise and Speckle noise with different values of embedding strength factor ($\alpha=0.1- \alpha=0.8$).

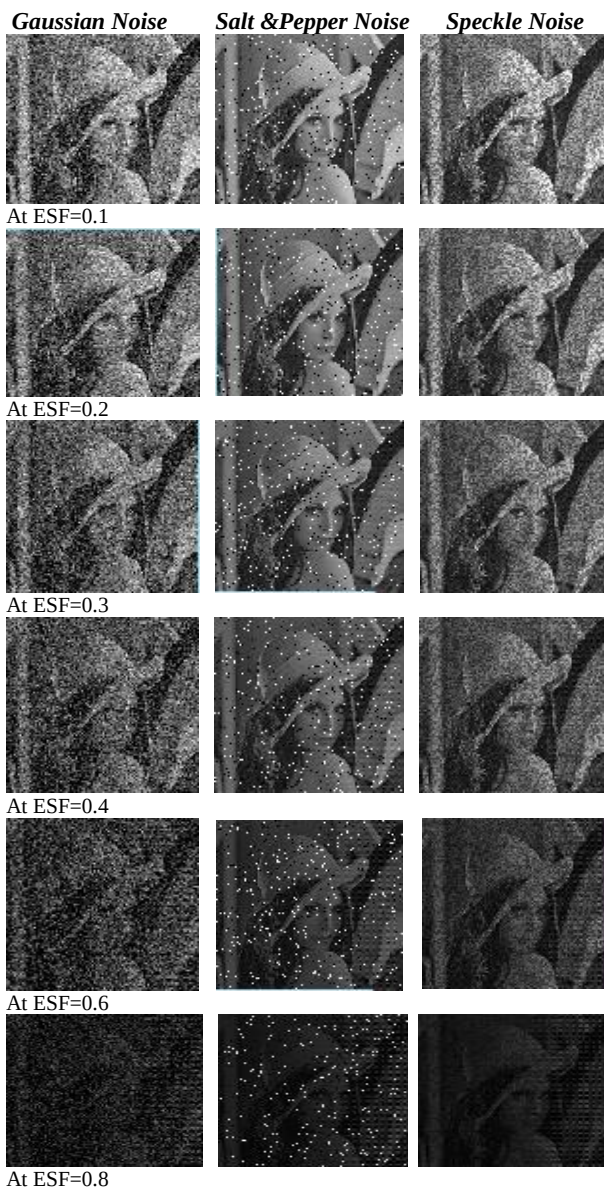


Fig. (3): Noisy Stego-images with different types of noise.

Figure (4) shows the Denoised Stego-images using Average filter, Median filte and Wiener filter at Gaussian Noise with different values of **ESF**. It is apparent from the visual inspection that the denoised Stego-images used Median Filter is better than Average Filter and Wiener Filter.

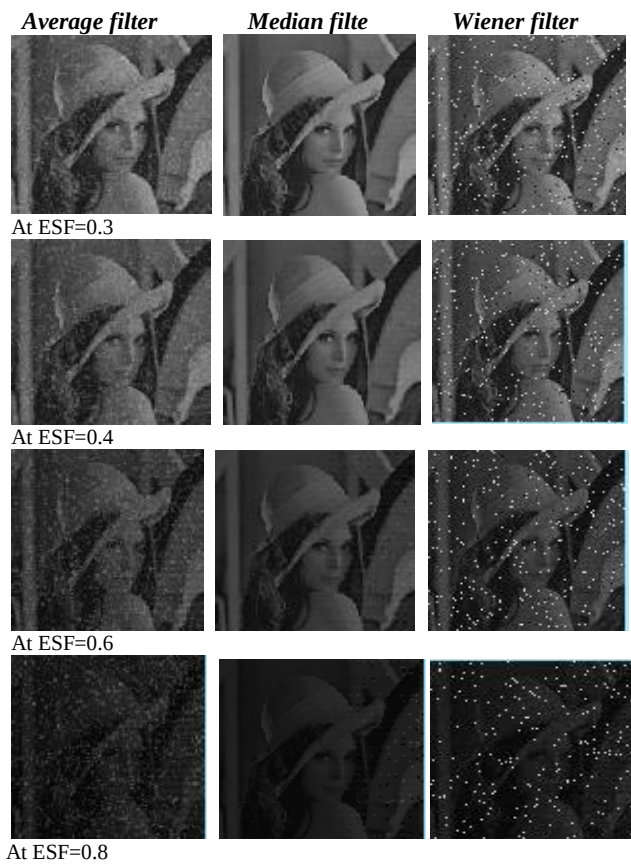
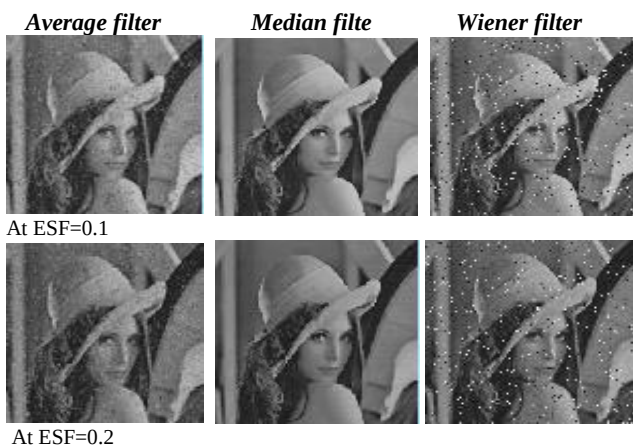
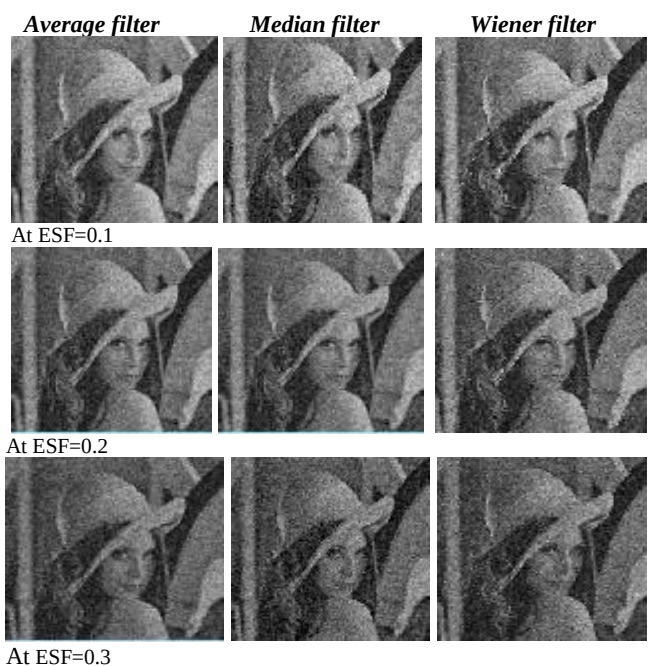


Fig. (4): Denoised Stego-images at Gaussian Noise.

Figure (5) shows the denoised Stego-images using Average filter, Median filte and Wiener filter at Salt&pepper Noise with different values of **ESF**. It is apparent from the visual inspection that the denoised Stego-images used Average Filter is better than Wiener Filter and Median Filter.



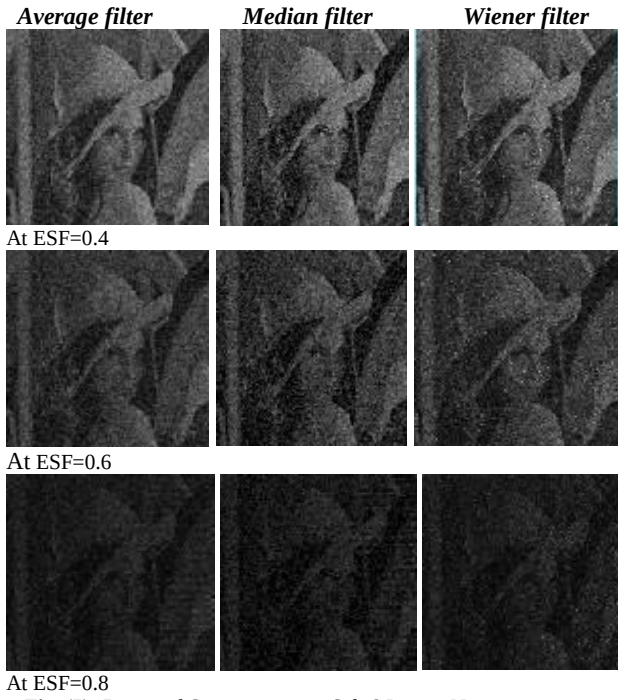


Fig. (5): Denoised Stego-images at Salt & Pepper Noise.

Figure (6) shows the denoisy Stego-images using Average filter, Median filter and Wiener filter at Speckle Noise with different values of **ESF**. It is apparent from the visual inspection that the denoised Stego-images used Average Filter is better than Wiener Filter and Median Filter.

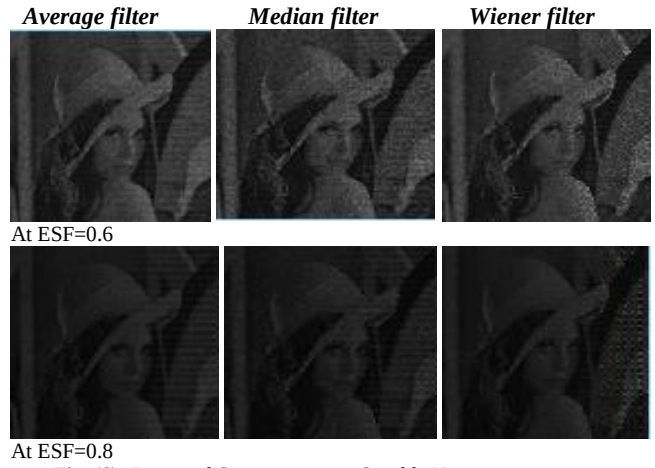
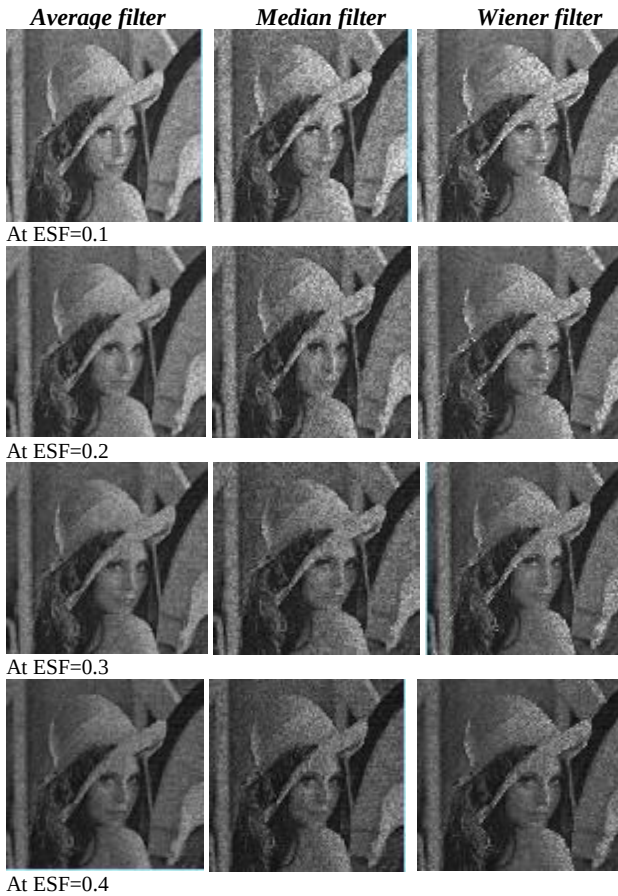


Fig. (6): Denoised Stego-images at Speckle Noise.

III. RESULTS AND DISCUSSION

Experiments were carried out on various standard gray scale cover images of size 256 x 256, which are shown in Figure (7). The Stego-images are corrupted by a simulated Gaussian white noise (mean=0, variance=0.01), Salt & Pepper noise (noise density= 0.05) and Speckle noise (mean=0, variance=0.04). For denoising process, various spatial linear filters (average filter (3x3), Wiener Filter (3x3)) and spatial nonlinear filter (median filter (3x3)) are used.



Fig. (7): Original Images used for simulation in which Lena used as cover, Locomotive and House used as secret.

The Quantitative performance of the Stego-system and filters are evaluated through:

a) Mean Square Error (MSE): The MSE can be defined as the distortion in the image or the measure of average of the squares of the Difference between the intensities of the stego- image and the cover image and it is represented as follows:

$$MSE = \frac{1}{M * N} \sum_{j=1}^M \sum_{k=1}^N (C(j, k) - S(j, k))^2 \quad (4)$$

Where: C (j, k), is the cover image, S (j, k) is the stego- image and M, N is the Size of the image [5].

b) Peak Signal to Noise Ratio (PSNR):

$$PSNR = 10 \log_{10} \frac{(255)^2}{MSE} \quad (5)$$

c) Cross Correlation coefficient:

$$COR = \frac{\sum_{j=0}^{N-1} (C(j, k) - m1)(S(j, k) - m2)}{\sqrt{(\sum_{j=0}^{N-1} (C(j, k) - m1)^2)(\sum_{j=0}^{N-1} (S(j, k) - m2)^2)}} \quad (6)$$

Where: C (j, k), is the cover image, S (j, k) is the Stego- image, m1 is the mean pixel value of the cover image and m2 is The mean pixel value of the Stego- image.

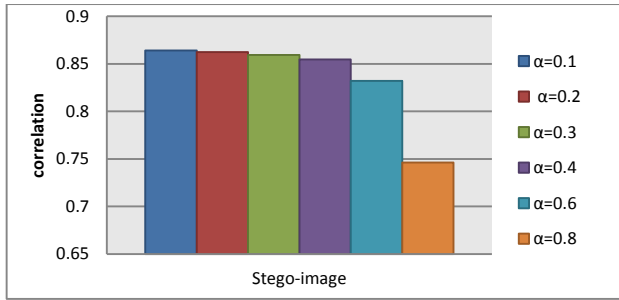


Fig. 8(a): Correlation of Stego-image with different values of alpha.

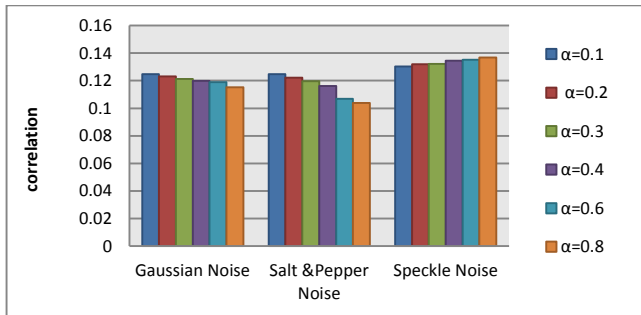


Fig. 8(b): Correlation of noisy Stego-image with different types of noise.

Figure (8) shows the Correlation of the Stego-image with different values of **ESF** when using Lena image as a cover and the Locomotive image as secret message, and at figure 8(a) the correlation of stego-image before passing in the noisy communication channel, and at figure 8(b) the correlation of Stego-image after passing in the noisy communication channel.

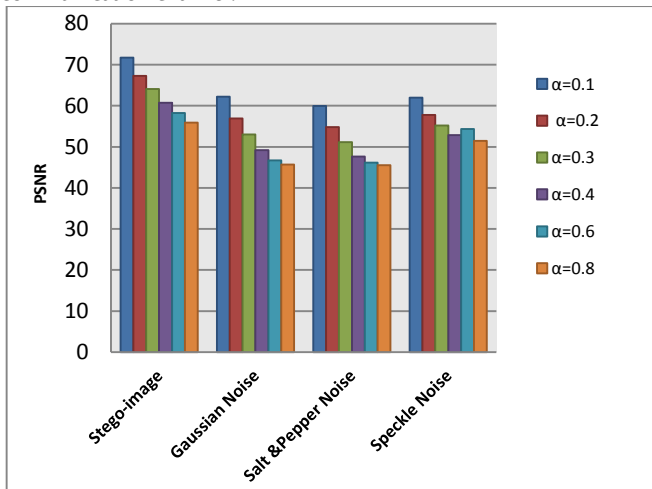


Fig. 9(a): PSNR of Stego-images and noisy Stego-images with different values of alpha.

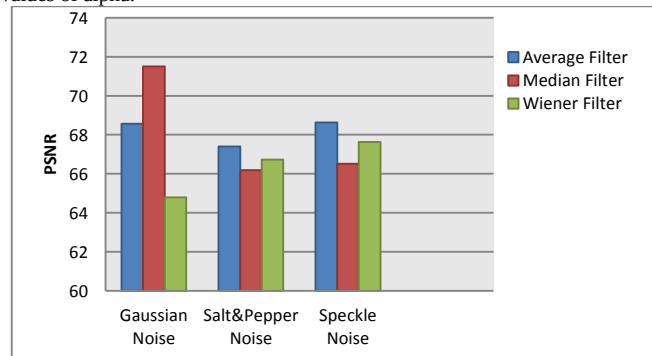


Fig. 9(b): PSNR of Denoisy Stego-images with different types of filters at value of ESF=0.1.

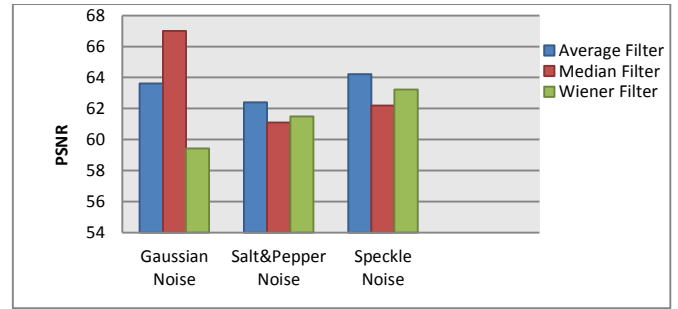


Fig. 9(c): PSNR of Denoisy Stego-images with different types of filters at value of ESF=0.2.

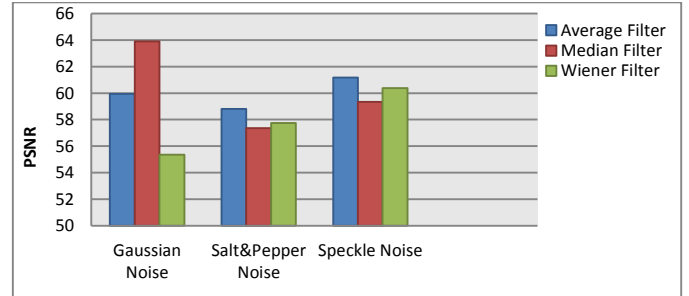


Fig. 9(d): PSNR of De-noisy Stego-images with different types of filters at value of ESF=0.3.

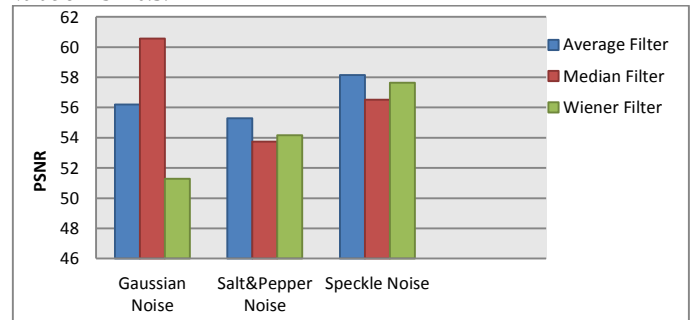


Fig. 9(e): PSNR of De-noisy Stego-images with different types of filters at value of ESF=0.4.

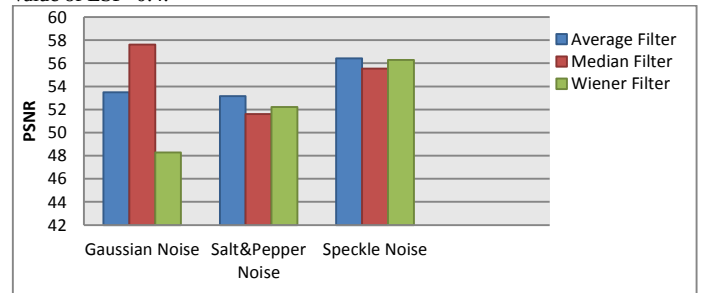


Fig. 9(f): PSNR of De-noisy Stego-images with different types of filters at value of ESF=0.6.

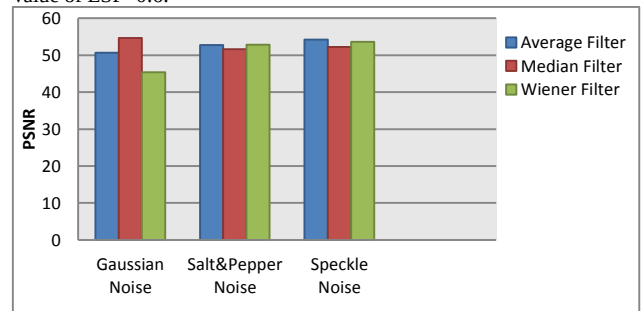


Fig. 9(g): PSNR of De-noisy Stego-images with different types of filters at value of ESF=0.8.

Figure (9) shows the (PSNR) of Stego-image with different values of **ESF** when using Lena image as a cover and the Locomotive image as secret message, and at figure9(a) the (PSNR) of Stego-image before passing in the noisy communication channel, when the Stego-image passing in the noisy communication channel, and at figure9(b-g) denoisy process performed for the noisy Stego-images using Average filter, Median filter and Wiener filter at Gaussian noise, Salt & pepper noise and Speckle noise when the value of embedding strength factor (**ESF**) from 0.1 to 0.8.

IV. CONCLUSIONS

In this paper, various noise models and filtering techniques (linear and nonlinear filtering) have been investigated. The different types of noises which include Gaussian noise, Salt & Pepper noise and Speckle noise were simulated on Stego-images. Then different spatial filters which include Average filter, Median filter and Wiener filter were applied on different noisy Stego-images. The performance of the Stego-system and filters are evaluated through: the Mean Square Error (**MSE**), Peak Signal to Noise Ratio (**PSNR**) and Cross Correlation coefficient (**COR**). The comparison results show that the average filter has better performance in removing Salt & Pepper noise and Speckle noise efficiently. The median filters performed well in removing Gaussian noise, Speckle noise and Salt & Pepper noise.

References

- [1] Mazhar Tayel, Hamed Shawky, Alaa Hafez "A New Hybrid Fuzzy-Decomposed Full Capacity Stego-System" 10th HONET-CNS, December 11-13, 2013.
- [2] Mazhar Tayel, Hamed Shawky "An Optimized Trade-off Decomposition Steganography Algorithm" International Journal of Computer Applications volume No. 86, January, 2014.
- [3] Saurabh V. Joshi, Ajinkya A. Bokil, Nikhil A. Jain, and Deepali Koshti "Image Steganography Combination of Spatial and Frequency Domain" International Journal of Computer Applications Volume 53- No.5, September 2012.
- [4] H S Manjunatha Reddy, K B Raja "Steganography based on Adaptive Embedding of Encrypted Payload in Wavelet domain " International Journal of Scientific & Engineering Research, Volume 3, Issue 8, August-2012.
- [5] Prabakaran. G, Bhavani.R "A Modified Secure Digital Image Steganography Based on Discrete Wavelet Transform" International Conference on Computing, Electronics and Electrical Technologies [ICCEET] 2012.



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