# A COMPARATIVE STUDY OF NOISE REMOVAL IN CDNA MICROARRAY IMAGE USING DIFFERENT FILTERING TECHNIQUES

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## Abstract

*In complementary Deoxyribonucleic Acid (cDNA) Microarray image noises usually occur during the accusation or while transmission. It is necessary to remove the noise to provide further processing techniques like edge detection, segmentation, etc. In this paper we gives comparative analysis to remove salt and pepper noise and speckle noise using different filtering techniques like standard median filter, switched median filter and vector median filter. The Mean Squared Error (MSE) and Peak Signal to Noise Ratio (PSNR) values are calculated for different density of salt and pepper noise and speckle noise. To find the better noise removal technique the comparison is done based on high PSNR value for different filtering techniques. The MATLAB based simulation is done to calculating the MSE and PSNR values.*

***Keywords:*** *Mean Square Error (MSE), Peak Signal To Noise Ratio (PSNR), Salt And Pepper Noise, Speckle Noise, Standard Median Filter, Switched Median Filter And Vector Median Filter.*

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## I. INTRODUCTION

The microarray image is considered to be the next generation development in bioinformatics to monitor thousands of genes simultaneously. A microarray image is an array of spots sequences arranged in the solid surface of glass slide. Every spots contains multiple collection of single DNA sequence [1].

During the process of experiment the mRNA of the two tissue of interest is extracted and purified, then each of the mRNA samples are reverse transcribed into its complementary Deoxyribonucleic acid (cDNA). They are labeled with two different fluorescent dyes which results into two fluorescence tagged cDNA (green CY3, red CY5). The tagged cDNA are hybridized in the glass slides.

The hybridized glass slide with fluorescent dyes is scanned at different wavelength where two different images are obtained. In the microarray image noise originates from different sources during the process of experiment, electronic noise, dust on the glass slide, due to laser light reflection and so on. Hence it is necessary to remove the noise for further processing [2-5]

In this paper a comparative analysis of different filtering techniques is implemented to remove salt and pepper noise and speckle noise. The filtering techniques implemented for comparison is standard median filter, vector median filter and switched median filter.

## II. TYPES OF NOISE.

*A. Salt and Pepper Noise.*

The salt and pepper noise is also called as impulse noise or spike noise. A typical variety of salt and pepper noise in a cDNA microarray image is the salt and pepper noise which will have dark pixel in bright region and bright pixel in dark region. The white pixel (salt) and black pixel (pepper) is the kind of disturbance to the image.

The noise density can be that of the salt and pepper noise in the image. The total noise density of nd in an $M \times N$ image is $nd \times M \times N$ pixel contains noise. In general, the complete noise density of salt and pepper is d then every salt noise therefore the pepper noise is nd/2 . The salt noise and pepper noise is different noise density nd1 and nd2, therefore the whole noise density will be

$$nd = nd1 + nd2 \quad (1)$$

*B. Speckle Noise.*

In cDNA microarray imaging technique speckle noise will be present so it is necessary to remove the speckle noise. Speckle noise is considered to be multiplicative noise can be represented by the equation as below:

$$n_{i,j} = nf_{i,j}\, m_{i,j} + a_{i,j} \quad (2)$$

were ni,j represents the noisy pixel, nfi,j is considered to be noise free pixel, $m_{i,j}$ is the multiplicative noise and $a_{i,j}$ is the additive noise respectively i, j are the spatial locations. Since the effect of additive noise is considerably small when compared with multiplicative noise (2) we can write as

$$n_{i,j} = nf_{i,j}\, m_{i,j} \quad (3)$$

where the speckle noise intensity $nf_{i,j}\, m_{i,j}$ is close to Gaussian noise [6]. The logarithmic transform of multiplicative form equation in (3) to additive noise is as

$$\log(n_{i,j}) = \log(nf_{i,j}) + \log(m_{i,j}) \quad (4)$$

$$x_{i,j} = y_{i,j} + n_{i,j} \quad (5)$$

were log ($n_{i,j}$) is the noisy image in the cDNA microarray image after the logarithmic compression is denoted as $x_{i,j}$ and the log $nf_{i,j}$ ,log $m_{i,j}$ are the noise free pixel and the noisy component after the logarithmic compression is $y_{i,j}\, n_{i,j}$.

## III. STANDARD MEDIAN FILTER

The non-linear filter is widely used to remove noise in an image than the linear filtering techniques because linear filtering technique will tend to remove the fine details of the image [7-12]. The standard median filtering method for the image window size taken is 3×3 where the noise and the noise free pixels are in the window. The median value is considered in order to replace the noisy pixel to noise free pixel. The detection of noisy pixel and noise free pixel are by considering the value of the processed pixel values which is between maximum and minimum value with in the selected window. The dynamic range of the impulse noise is (0, 255). When the value is of the range (0, 255) it is considered to be corrupted by the impulse noise and the remaining pixels are the same [13], [14].

If the dynamic range of the pixel is not between (0, 255) then it is a noisy pixel and it is replaced by the median value or the neighborhood value of the window. By replacing the median value of each window the impulse noise is removed. Hence we get a noise free image. Similarly the speckle noise is removed with the standard median filter.

*Algorithm for Standard Median Filter*

STEP 1: Read the noisy image I.
STEP 2: Convert the colour image to gray scale image G.
STEP 3: Pad the G with zeros at the boundaries to form padded matrix P.
STEP 4: Take the 3×3 matrix of pixels from the padded matrix P.
STEP 5: Calculate image median and replace pixel in the image with the median.
STEP 6: Repeat for all possible 3×3 matrix and replace all pixel with the median value.
STEP 7: Display the denoised output image.
STEP 8: Calculate the MSE and PSNR value.

## IV. SWITCHED MEDIAN FILTER.

The switched median filter (SMF) is popularly used to remove the impulse noise. The SMF will provide better denoising in an image [15-19]. The switched median filter it switches for the certain condition. We take the window size to be 3×3 in the matrix. Then we calculate the maximum value in the window $W_{max}$, the minimum value $W_{min}$ and the median value M.

When $W_{min}$<M && M< $W_{max}$, if this condition satisfies then we replace the fifth value in the window if not the condition is checked if it is satisfied then the median value is replaced or else the mean value of the window is replaced. The switching median filter will remove the impulse noise and the speckle noise.

*Algorithm For Switched Median Filter*

STEP 1: Read the noisy image I.
STEP 2: Convert the colour image to gray scale image G.
STEP 3: Pad the G with zeros at the boundaries to form padded matrix P.
STEP 4: Take the 3×3 matrix of pixels from the padded matrix P.
STEP 5: Calculate maximum pixel in the window Wmax.
STEP 6: Calculate minimum pixel in the window Wmin.
STEP 7: Calculate median in the window M.
STEP 8: Check the condition if Wmin<M && M< Wmax satisfies then B(i ,j) = 0 if not move to the next step.
STEP 9: Check the condition if Wmin<M && M< Wmax satisfies then B(i ,j) = M if not move to the next step.
STEP 10: Replace B(i ,j) = mean(window).
STEP 11: Repeat for all possible 3×3 matrix and replace all pixel with the median value.
STEP 12: Display the denoised output image.
STEP 13: Calculate the MSE and PSNR value.

## V. VECTOR MEDIAN FILTER

The vector median filter (VMF) is a nonlinear filter. The VMF is a well-researched and widely used due to extensive modified that can perform in conjunction with it to avoid the damage to the noise free pixel [20-22].

In the vector median filter the noisy image is taken and the 3×3 window is considered for the complete image. Every pixel in the matrix is considered to be checked for the conditions VMF = W(i) where $1< i \leq 9$ in the window.

$\|VMF - W\| \leq \|W_i - W\|$ for $1< i \leq 9$

If the condition satisfies then we replace with the obtained value. The complete image follows the same process there by the impulse noise and the speckle noise is removed.

*Algorithm For Vector Median Filter*

STEP 1: Read the noisy image I.
STEP 2: Convert the color image to gray scale image G.
STEP 3: Pad the G with zeros at the boundaries to form padded matrix P.
STEP 4: Take the 3×3 matrix of pixels from the padded matrix P.
STEP 5: Take one pixel at a time as VMF, VMF = W(i).
STEP 6: Check the condition || VMF – W|| ≤, ||Wi – W|| for 1< i ≤.9 if it satisfies then move to step 7.
STEP 7:Replace B(i ,j) = VMF .
STEP 8: Repeat for all possible 3×3 matrix and replace all pixel with the median value.
STEP 9: Display the denoised output image.
STEP 10: Calculate the MSE and PSNR value.

The MSE and PSNR value is calculated by using the formula

$$PSNR = 20.\log_{10}(MAX_I) - 10.\log_{10}(MSE) \qquad (6)$$

Where,

$$MSE = 1/(m\,n) \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} [I(i,j) - K(i,j)]^2 \qquad (7)$$

The MSE AND PSNR value is calculated for different density of the salt and pepper noise and speckle noise for different filtering techniques.

## VI. EXPERIMENTAL RESULT

Image format: jpeg, Dimension 320×240, color Image.

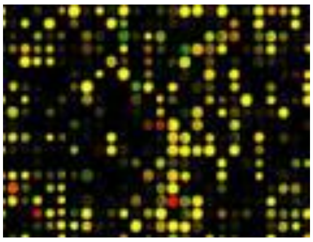
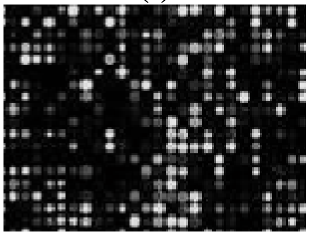
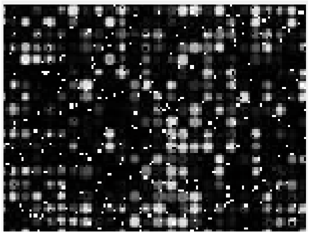
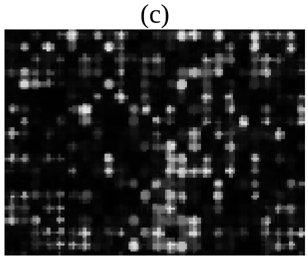
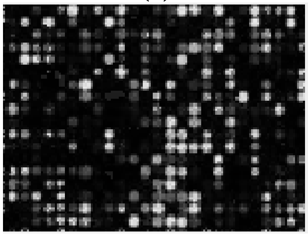
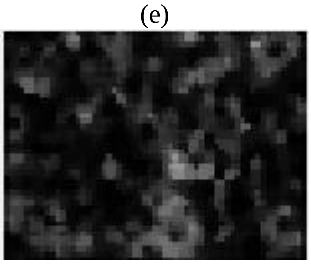

(a)

(b)

(c)

(d)

(e)

(f)

**Fig 6.1**:Microarray image a)Original image b)original image converted to grey scale image c)Image corrupted with 5% salt and pepper noise d)Noise removed by standard median filter e)Noise removed by switched median filter f)Noise removed by vector median filter.

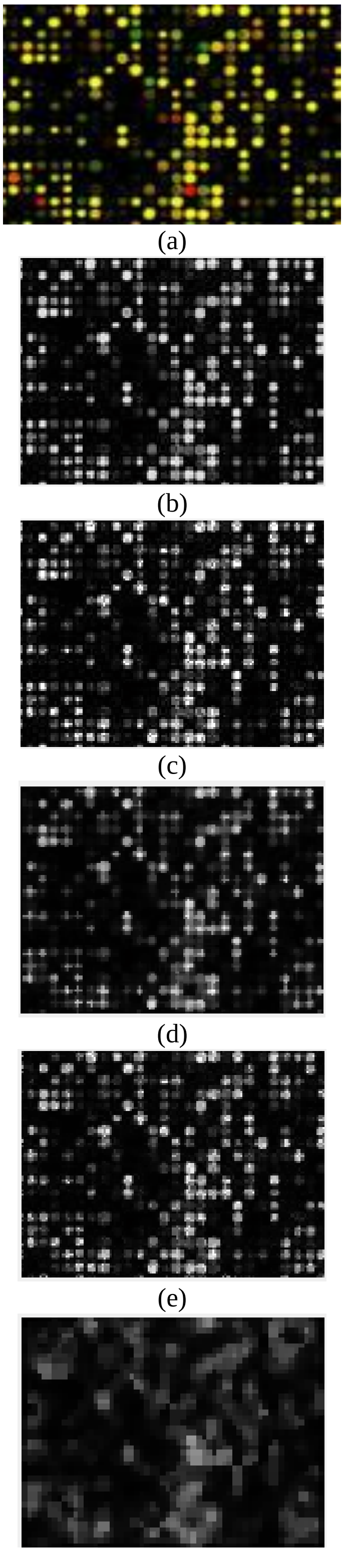



**Fig 6.2:** Microarray image a)Original image b)original image converted to grey scale image c)Image corrupted with 5% speckle noise d)Noise removed by standard median filter e)Noise removed by switched median filter f)Noise removed by vector median filter.

**Table 1:** Comparison of MSE for different density of salt and pepper noise.

| Noise Density (percentage) | Standard Median Filter | Switched Median Filter | Vector Median Filter |
|---|---|---|---|
| 5 | 56.8091 | 12.0091 | 61.0256 |
| 10 | 56.3756 | 13.2741 | 54.7669 |
| 20 | 53.0787 | 17.2413 | 43.4889 |
| 30 | 56.336 | 22.5522 | 39.5013 |
| 40 | 53.7415 | 23.9287 | 32.7017 |
| 50 | 56.6913 | 30.7837 | 28.5507 |
| 60 | 56.2119 | 31.0514 | 24.5013 |
| 70 | 59.4822 | 34.8461 | 23.0373 |

**Table 2:** Comparison of PSNR ( db) for different density of salt and pepper noise.

| Noise Density (percentage) | Standard Median Filter | Switched Median Filter | Vector Median Filter |
|---|---|---|---|
| 5 | 30.5866 | 37.3357 | 30.2737 |
| 10 | 30.6199 | 36.9007 | 30.7456 |
| 20 | 30.8816 | 35.7651 | 31.7471 |
| 30 | 30.6229 | 34.5989 | 32.1647 |
| 40 | 30.8277 | 34.3416 | 32.9851 |
| 50 | 30.9556 | 33.2476 | 33.5746 |
| 60 | 30.6325 | 33.0907 | 34.2389 |
| 70 | 30.3869 | 32.7093 | 34.5065 |

**Table 3:** Comparison of MSE for different density of speckle noise.

| Noise Density (percentage) | Standard Median Filter | Switched Median Filter | Vector Median Filter |
|---|---|---|---|
| 5 | 65.1788 | 35.8284 | 69.6893 |
| 10 | 65.3576 | 35.7865 | 69.4881 |
| 20 | 72.4508 | 49.4543 | 71.6738 |
| 30 | 75.9518 | 53.6106 | 73.3755 |
| 40 | 78.2751 | 54.7695 | 74.5849 |
| 50 | 78.5164 | 56.2359 | 74.7352 |
| 60 | 80.8635 | 57.6882 | 74.6177 |
| 70 | 80.6805 | 57.2918 | 73.4422 |

**Table 4:** Comparison of PSNR (db) for different density of speckle noise.

| Noise Density (percentage) | Standard Median Filter | Switched Median Filter | Vector Median Filter |
|---|---|---|---|
| 5 | 29.9897 | 32.5885 | 29.6991 |
| 10 | 29.9778 | 32.5936 | 29.7117 |
| 20 | 29.5304 | 31.1888 | 29.5772 |
| 30 | 29.3254 | 30.8383 | 29.4753 |
| 40 | 29.1946 | 30.7454 | 29.4043 |
| 50 | 29.1812 | 30.6307 | 29.3956 |
| 60 | 29.0533 | 30.5199 | 29.4024 |
| 70 | 29.0631 | 30.5499 | 29.4422 |

## VII. CONCLUSION

In this paper different filtering technique are analyzed to remove salt and pepper noise and speckle noise in the images. In the implemented system the standard median filter, switched median filter and vector median filter removal of the noise is effective while preserving the quality of the image. Also the PSNR is calculated to compare the better noise removal filter in microarray images. Matlab based implementation is carried out for all the filtering techniques. The PSNR ratio and the MSE is the performance comparison. This paper can be extended by comparing other various filtering techniques to remove the noise in the microarray images it also be further extended by using the lifting scheme technique combining with wavelet thresholding method which would be implemented in the future works.

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