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Microarray Image De-noising

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***Abstract*— DNA microarray caters varieties of applications from disease diagnosis to human identification. In practice, the microarray image is corrupted with various noises. As a result the gene intensities extracted from the dye are inaccurate which, in tur n affects the accuracy of cancer classification. In this paper, we suggest to use Median filter and wavelet transform based filters to de-noise the microarray image. For different values of mean and standard deviation of the Gaussian noise the performance of Median and wavelet transform based filters is compared.**

***Keywords*— Messenger ribo-nucleic acid, complementary Deoxyribo nucleic acid, mean square error, peak signal to noise ratio.**

I. INTRODUCTION

Microarray technology is recent cutting edge technology in bioinformatics to monitor the expression levels of thousands of genes simultaneously[1][2].Microarray applications vary from cancer diagnosis to human identification[3].Microarrays are predicted to be a normal diagnostic method in future much like today's blood test[1]. Microarray technology has three crucial steps: microarray experiment, image processing and data analysis [2].

In microarray experiment, first the mRNA is extracted from the normal cell and the cancerous cell. The mRNA is then converted into cDNA and labeled with different dyes (red, green).Following this step cDNA is hybridized onto microarray slide. The microarray slide is then excited with laser at suitable wavelength to detect red and green dyes. The final microarray image is stored as a file for further processing. The microarray image consists of thousands of spots. Each spot contains many copies of the same DNA sequence that uniquely represents a gene [2].

In practical microarray image the spots are not aligned properly, they are not circular in shape, the background intensity is affecting the spot intensity. Microarray image is corrupted with several types of noises. Due to all these problems microarray image requires further processing before using it for cancer sub-classification. The major steps in microarray image processing are de-noising, gridding, segmentation and quantification.

Microarray image is corrupted with various noises like sample preparation noise, scanning noise and hybridization noise which, are introduced during the microarray experiment. Sample preparation noise is introduced in the process of converting mRNA-cDNA. The mRNA molecules are amplified by factor A. The factor A varies from one sample preparation to other. It is also due to intrinsic chemical process involved in sample preparation. Noise during Scanning is due to photon noise, electron noise in photo multiplier tube, laser light leakage, reflection and quantization noise. Hybridization noise comes due to fluctuation in both target molecules binding and cross hybridization. The number of ways to reduce the noise are [1]

a. By accurately adjusting the fabrication machine, fluorescent machine and normalizing the experimental conditions.
b. By designing suitable filter.

Even after improving the experimental conditions largely, the noise still exists. Therefore the better way to reduce the noise is by designing suitable filter. The reduction of the noise from the micro array image can be performed in the pixel domain (filters) [5], [6], [7] or in the transform domain (PCA, Wavelets etc.)[8], [9], [10].

We propose to Median filter and wavelet transform based filters to remove noise from microarray image. In this paper, section II describes the methodology, section III shows the details of the implementation, followed by result analysis in section IV.

II. METHODOLOGY

A. Median filter

It is nonlinear spatial domain filter. It replaces the central pixel by median of gray levels in neighborhood of that pixel. Median filter forces pixels with different gray levels to be more like their neighbors. This filter works very well for random noise.

Algorithm:

1. Place the filter mask at initial position in the image.

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2. Sort the image pixels of the mask in ascending order.
3. Replace the central pixel by Median of all pixel values in the mask.
4. Repeat the procedure by sliding the mask all over the image for every pixel in the image.

B. Wavelet Transform based technique:

Wavelet analysis is capable of revealing aspects of data that other signal analysis techniques miss; aspects like trends, breakdown points, discontinuities in higher derivatives, and self-similarity. It affords a different view of data than those presented by traditional techniques, wavelet analysis can often compress or de-noise a signal without appreciable degradation. Various types of wavelets afford flexibility and ease of comparison. The custom made filters of wavelet transform work well in an image noise reduction [11].

Algorithm:

1. Decompose - Choose a wavelet. Compute the wavelet decomposition of the signal.
2. Threshold detail coefficients - Threshold the detail coefficients.
3. Reconstruct - Compute wavelet reconstruction using the original approximation coefficients and the modified detail coefficients.

The detail coefficients are the high frequency coefficients which includes information about edges and noise. Noise is present in high frequency components and edges are present in the frequency components higher than noise frequency components. In order to remove noise and preserve edges it is necessary to select the threshold correctly.

The threshold is selected by using Visushrink

$$th = sig\sqrt{2\log n}$$

where,

sig = variance of noise in an image
= median (absolute (detailed coefficient.))/0.6745
n=number of pixels in an image

The detail coefficients to be used for an image reconstruction are decided using hard and soft thersholding. In case of hard thresholding the wavelet coefficients less than threshold are made zero and coefficients larger than threshold remain same. The formula for hard threshold is given as

$$coe = w; |w| >= th$$

$$coe = 0; |w| < th$$

where,

coe = detailed wavelet coefficients after thresholding

w = detailed wavelet coefficients before thresholding.

In case of soft thresholding the wavelet coefficients less than threshold are made zero and coefficients larger than threshold are not retained. The formula for soft threshold is given as [12]

$$coe = sign(w)(|w| - th); |w| >= th$$

$$coe = 0; |w| < th$$

The quality of de-noised image is checked by using parameters:

a. MSE: Mean square error: Cumulative error between noisy image and noise image.

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

b. PSNR: Peak signal to noise ratio.

$$PSNR = 10\log\left(\max(I)^2 / mse\right)$$

Where,

I= Original image,
K= De-noised image,
max I= 255 for 8 bit image.

III. Implementation

The microarray image is generated using Microarray Scan Simulator [12]. The microarray image is as shown in Figure (1).

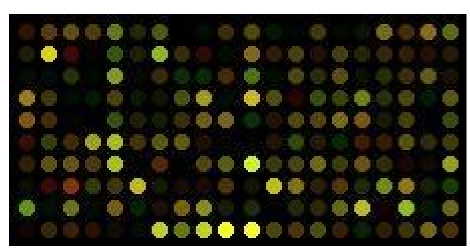

Figure (1) Microarray image.

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In order to de-noise the microarray image first the Gaussian white noise with zero mean, known variance and Poisson's noise are added to microarray image. The resultant noisy image is de-noised using Median filter and wavelet transform based technique.

IV. Result

The mean square error and peak signal to noise ratio for different de-noising methods is as shown below

TABLE I
MEDIAN FILTER RESULTS

Sr.no	Mean and variance	Median	
		MSE	**PSNR**
1	0,0.5	40.9147	32.0125
2	0,2.5	42.9238	31.8048
3	0, 5	48.0221	31.3169
4	0,25	168.6939	25.8603
5	0,50	440.1427	21.6950
6	0,75	799.7953	19.1012

TABLE II
VISUSHRINK HARD THRESHOLDING RESULT

Sr.no	Mean and variance	Hard Thresholding	
		MSE	**PSNR**
1	0,0.5	17.5802	35.6808
2	0,2.5	23.0874	34.4971
3	0, 5	38.8171	32.2406
4	0,25	250.6063	24.1410
5	0,50	762.0978	19.3120
6	0,75	1486.1	16.4103

TABLE III
VISUSHRINK SOFT THRESHOLDING RESULT

Sr.no	Mean and variance	Soft Thresholding	
		MSE	**PSNR**
1	0,0.5	64.1891	30.1681
2	0,2.5	71.0326	29.7149
3	0, 5	3.9445	28.9502
4	0,25	274.709	23.7445
5	0,50	715.203	19.5867
6	0,75	1400	16.6677

V. Conclusion

As microarray image has large number of edges, wavelet based hard thresholding works better than the soft thresholding and Median filter for lower values of variance of noise. For higher values of noise variances Gaussian noise appears like salt and pepper noise in the image and Median filter works better than wavelet filters.

REFERENCES

[1] X. Y. Zhang, F. Chen, Y. Zhang, S. C. Anger, M Akay, Z. Lu, M. M. Y. Waye and S. K. Tsui, "Signal Processing Techniques In Genomic Engineering", Proc. IEEE, Vol. 90, No. 12, Pp.1822-33, Dec. 2002.

[2] X. H. Wang, Robert S. H. Istepanian and Y. H. Song ,"Microarray Image Enhancement by De-noising Using SWT" , IEEE Transactions on nano-bioscience, Vol. 2 , No. 4, Pp. 184-189, Dec. 2003.

[3] A. Fouad, F. Labib, A. Sharawy, M. Mabrouk, "Developing a New Methodology for De-noising and Gridding cDNA Microarray Images", IEEE Cairo Int.

[4] Y. Tu, G. Stolovizky, U. Klein, "Quantitative Noise Analysis For Gene Expression Microarray", Proc. Nat. Acad. Sci, U. S. A, Vol. 99, No. 22, Pp. 14031-36, 2002.

[5] R. Lukac, K. N. Plataniotis, B. Smolka, and A. N. Venetsanopoulos, "A multichannel order-statistic technique for cDNA microarray image processing," IEEE Trans. Nanobiosci., vol. 3, no. 4, pp. 272–285, Dec.2004.

[6] R. Lukac and B. Smolka, "Application of the adaptive centerweighted vector median framework for the enhancement of cDNA microarray images," Int. J. Appl. Math. Comput. Sci., vol. 13, no. 3, pp. 369–383, 2003.

[7] P. O'Neill, G. D. Magoulas, and X. Liu, "Improved processing of microarray data using image reconstruction techniques," IEEE Trans. Nanobiosci., vol. 2, no. 4, pp. 176–183, Dec. 2003.

[8] S.Li, C. Liao, J. Kwok, "Wavelet Based Feature Extraction for Microarray Data Classification", IEEE Int.Conf. On Neural Network, Canada, Pp.5028-5033, July 2006.

[9] M. Sarhan, "Cancer Classification Based On Microarray Gene Expression Data Using DCT And ANN", Journal of Theoretical and Applied Information Technology Pp.208-216, 2005-2009.

[10] V. Kumar, J. Sachdeva, I. Gupta,N. Khandelwal, C.K. Ahuja,"Classification Of Brain Tumors Using PCA-ANN", IEEE World Congress on Information and Communication Technologies,Pp.1079-1083,2011.

[11] Lat Soman, K. P. Insight into wavelets: from theory to practice. PHI Learning Pvt. Ltd., 2010.

[12] www.cybertory.org/downloads/mss/MSS040605.zip