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Noise Reduction and Background Correction for Noisy Microarray Images

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ABSTRACT

In this paper new techniques have been proposed to reduce noise and to correct the background in noisy microarray images. Noise reduction is done by eliminating artifacts through estimated robust threshold. Noisy pixels attached to the regular spots are being clustered and by splitting up the touching spots in noisy microarray images. Background correction is achieved through reducing the number of zero columns and zero rows to avoid unwanted background processing in the subsequent stages of microarray analysis. The proposed approach provides promising results for TBDB, SMD and UNC microarray images.

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INTRODUCTION

Microarray (Schena, M., *et al*., 1995) can be defined as collection of spots which contains DNA deposited at the surface of a glass slide. Every spot has multi-copies of each DNA sequence. Detectable light is emitted by the probes which are tagged with DNA florescent molecules when stimulated by laser. The detector records the light intensity, when the light is emitted. The slide produce large image with thousands of spots, when the laser scans slide.

Microarray image analysis (Kerr, M.K., *et al*., 2001) has three basic steps: assigning the image to spot by identifying the image is known as gridding. Secondly, segmentation explains separation between foreground and background pixels. Finally, information extraction is the average computation of foreground and background intensities for each spot of array.

The DNA microarray image technology has created advantages to develop the applications (Yuk Fai Leung and DuccioCavalieri, 2003) in diagnosis of human body and agricultural field. During the human body diagnosis, it can empower to explore genetic causes of anomalities, treatments and it also helps in determination of risk factors, disease stage and treatment progress. But this technology also has defaults causing errors such as, sources of high level noise, photon noise, electronic noise, dust on slide which may create difficult in identification of genes as which cells express accurate biological conclusion (ROBERT, S.H., 2003).

As image gets corrupted by noise sources, it results in wrong identification of microarray image. So, it is highly précised to identify and clear these errors. Therefore, proper method should be adopted to clear low quality images and it should be so enhanced for higher image processing for appropriate results. Image enhancement improves the image quality, by redefining the image texture, structural content, edges and presence of noise.

Related Work:

It's been observed that only few researches were carried out in the area of microarray image enhancement. X.H.Wang, Robert . S. H .Instepanian and Young Hua Song have explained a new concept as Wavelet theory for denoising technique by ensuring better gene expression. This metod is worked by application of stationary wavelet transform for pr-process the microarray images by removing random noises. RastislavLukac and BogdanSmolka (2003) came with novel method of noise reduction which attenuates both impulse and gauassian noise, during preservation and denoising sharpness of edges of images. R.Lukac, *et al* (2004) explained about vector fuzzy filtering framework which denoisecDNA microarray images, which determines the weights in the filtering structure by providing different filtering structures. Mario MastrianiandAlberto.E.Giraldez (RastislavLukaca, *et al*., 2005) have propsed noise removal by smoothening of coefficients of highest sub bands in wavelet domain. N.Plataniotis *et al*., (205) explained

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impulse detection mechanism using peer group concept in denoiseswiching system. Harastefanou, ThanasisMargaritis, DimitrisKafetzopoulos, Konstantinos Marias and Panagiotis Tsakalides (Peter Bajcsy, 2005) proposed a two-stage approach in denoising process by additive and multiplicative noise component which decomposes signal by multi resolution transform.Guifang Shao, Hong Mi, Qifeng Zhou and LinkaiLuo (Smolka, B., *et al.*, 2006) proposed a new concept of denoising which two parts as edge noise reduction and highly fluorescence noise reduction. Ali Zifan, Mohammad Hassan Moradi and ShahriarGharibzadeh came up with an approach using decimated and undecimated multi wavelet transforms. Tamana Howlader *et al* (2007) discussed about denoising of microarray images by standard maximum posteriori and minimum linear mean square error estimation criteria. J K meher *et al* (2007) explained noise reduction from microarray image and reduction of error during quantification process for estimating microarray spots accurately by preprocessing techniques such as optimize spatial resolution (OSR) and spatial domail filtering (SDF) to determine expression level of genes.Wengguirong proposed filtering method for denoising of noisy microarray images using edge enhancing diffucsion. Yogananda Balagurunathan *et al* (Pooria Jafari Moghadam, *et al.*, 2007) has explained about factorial analysis to study the effects and interaction of noise types at different noise levels on simulated microarray images. Chaitragoplappa *et al.*, (Mastrogianni Aikaterini *et al.*, 2007) explained about identification and scanning noise from microarray images using dual tree complex wavelet transform. Rammurugesan *et al* (Sarder, P., *et al.*, 2008) proposed two phase scheme for removing impulse noise by preserving the feature of interest in microarray images. Araunakumarkakuni *et al.*, (Chaitra Gopalappa, *et al.*, 2008) explained denoising using independent component analysis.Rastaslavlukac *et al* (2009) approached with an enhancement principles of fuzzy logic in congestion with data adaptive filter to enhance noisy microarray images. Wang Li Qiang *et al* (2009) presented reduction of impulse noise by switching scehme which uses differences between standard deviation of the pixels within filter window and the current pixels of concern. Nader suffarian *et al* (2010) approached with an implementation as conditional sub block bi-histogram equalization which has ability to improve the DNA microarray analysis by gridding.

Literature survey reveals that very few research papers are concentrated on background correction, so proposed method is concentrated on background correction for noisy microarray images

Proposed System:

Let I(x, y) is the microarray subgrid which contains x rows and y columns, the proposed algorithms in this paper can be realized as follows. In this section two algorithms are presented for noise reduction and background correction of noisy microarray images.

A. Noise Reduction:

i. Let bw(x,y) is the binary version of I(x,y). Robust threshold (T_A) is estimated using equation 1 to eliminate artifacts in the noisy microarray image.

$$\left(T_A = (\sqrt{T_C / K}\right) \qquad (1)$$

Where T_C is the total number of pixels and K is the number of connected components. If the number of pixels in a component is less than threshold value (T_A) in each segment, then remove the spot (insignificant pixles) by seting intensity zero to all pixels in that component. Let $b_{TA}(x,y)$ is the resultant image

ii. To remove undesirable pixels attached to regular spots as shown in fig.1(a) , morphological open is performed on $b_{TA}(x,y)$ with disk structuring element S of radius 5. Let $b_{op}(x,y)$ is the resultant image .

$$\left(b_{op}(x, y) \circ S = ((b_{TA}(x, y)\Theta S) \oplus S)\right) \qquad (2)$$

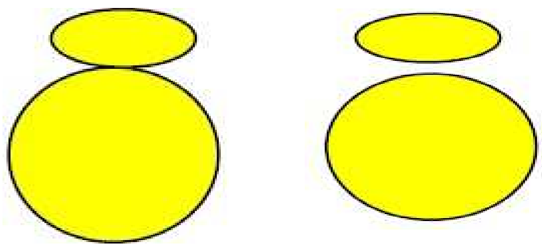

Fig. 1: (a) Before Open ; (b) After Open

iii. To differentiate attached regular spots shown in fig. 2 (a) an erosion is imposed on bop(x,y) with disk structuring S element of radius 5. Let $b_{nf}(x,y)$ is the resultant image as shown in fig.2(b).

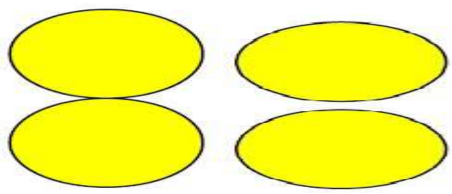

Fig. 2: (a) Before Erosion ; (b) After Erosion

B. Background Correction:

Let $b_{nf}(x,y)$ is the denoised subgrid obtained from section A .Background correction algorithm can be realized as follows.

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i. In $b_{nf}(x,y)$ subgird cloumnwise summation of pixels value is estimated to identify zero columns using the following equation and to store in an array called csum(y).

$$csum(y) = \sum_{i=1}^{x} \sum_{j=1}^{y} b_{nf}(x, y) \qquad (3)$$

Where y is the number of columns.

ii. The total number of zero columns are estimated from csum(y) using the following a segment of code.

```
zc=0;
for i=1:y
begin
if(csum(i)==0)
begin
zc++;
end
end
```

iii. The zero sum band is detected between non zero band. Where band is the set of zero columns. Let M is the zero columns at first and last band .Let N is the number of zero columns between non zero columns. Among M zero columns only three and among N zero columns only two are retained for the further processing of microarray images.

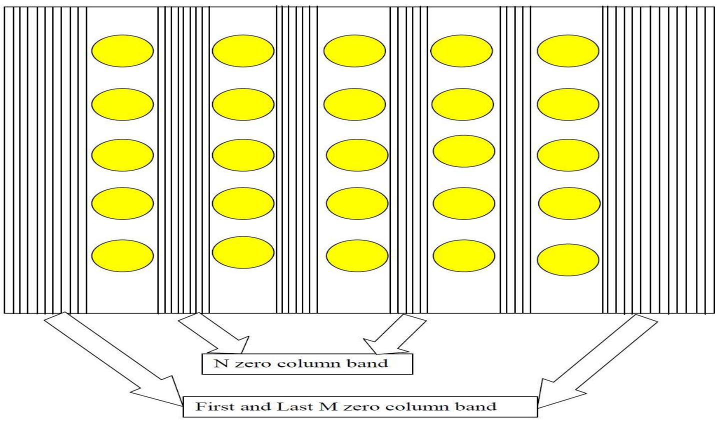

Fig. 3: Microarray subgrid before background correction

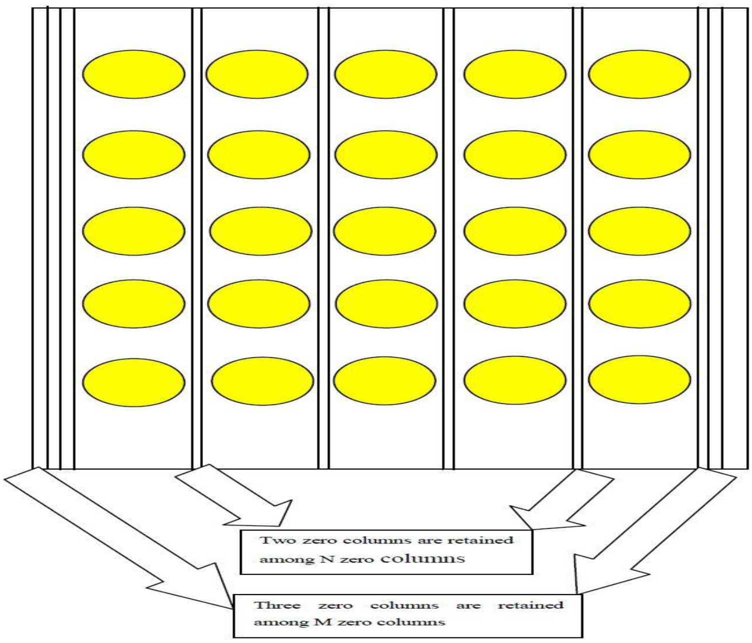

Fig. 4: Microarray subgrid after background correction

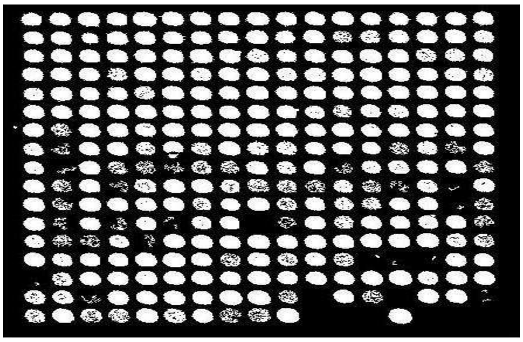

Fig. 5: Noisy Microarray subgrid (SMD)

Fig.3 shows microarray subgrid before background correction and fig.4 shows microarray subgrid after background correction. Three steps are repeated to get zero rows for transposed image of $b_{nf}(x,y)$.

Results:

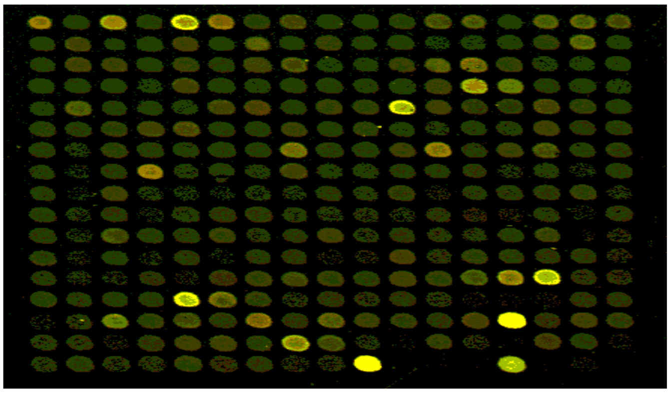

Fig. 6: Microarray subgrid with artifacts (SMD)

In this section, the performance of the proposed approach is evaluated on real noisy microarray images drawn from SMD (Stanford microarray database), UNC (University of North California microarray database) and TBDB database. Fig 5 shows noisy microarray subgrid.

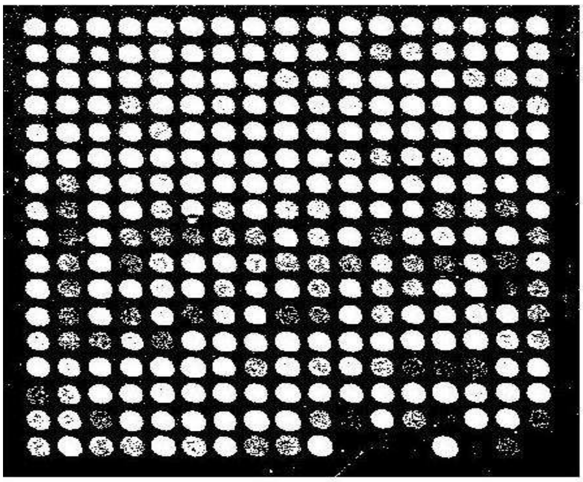

Fig. 7: Artifacts are removes using T_A (SMD)

Fig.6 shows noisy microarray subgrid with artifacts at all the corners of the image. and these are removed using robust threshold value as proposed in section A . In fig.7 it has been observed that artifacts are eliminated in the image which will help to identity zero columns and zero rows.

Table 1: Threshold values for Noisy Microarray Subgrids

Parameters	Value
Img1	7
Img2	6
Img2	19
Img4	11
Img5	14

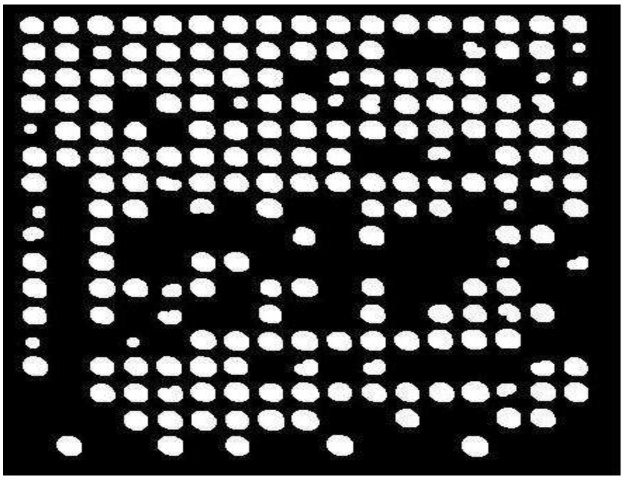

Fig. 8: Effect of Open and Erosion Operation, (SMD)

Fig 8 shows resultant image after step 2 and 3 as discussed in section A. In this image zero columns and rows are neatly identified and there are no noisy pixels between nonzero bands.

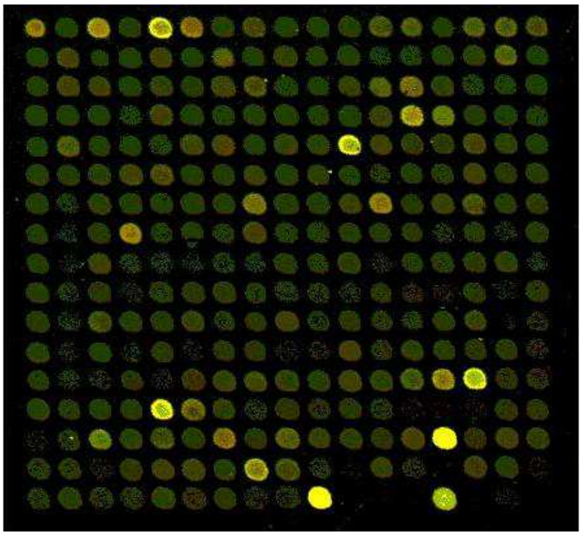

Fig. 9: Before Background Correction (SMD)

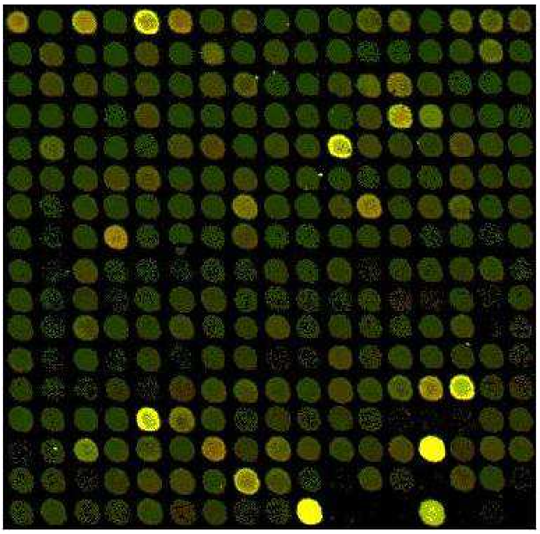

Fig. 10: After Background Correction (SMD)

Fig .9 shows microarray subgrid with unwanted background and fig.10 shows background corrected image after applying the algorithm as discussed in section B.

The PSNR value can be computed using equation 4.

$$PSNR=10 \log_{10} \frac{L^2}{MSE} \quad (4)$$

L reflects the range of values that a pixel can take and MSE is mean square value. Higher the peak signal to noise ratio value higher is the quality of the image and lower the mean squared value higher is the image quality. Here we have compared with Vishushrink, Edge smoothing filter and optimized resolution filter.

Table 2: PSNR values in db for Noisy Microarray Subgrids

Image	PSNR in DB			
	Proposed	visushrink	Edge Smoothing Filter	OF
Img1	20.52	14.32	5.05	5.07
Img2	18.32	5.45	12.93	13.72
Img3	20.90	15.48	17.84	19.96
Img4	17.68	15.54	15.28	15.00
Img5	19.17	7.73	12.79	14.31
Img6	20.27	12.48	11.03	13.28
Img7	21.26	3.72	16.82	19.76
Img8	20.32	11.00	14.18	14.88
Img9	19.41	12.83	14.97	16.12
Img10	21.90	16.57	19.13	20.22
Img11	18.30	12.58	15.27	15.14
Img12	17.74	13.14	14.40	14.43
Img13	15.15	10.32	10.09	11.61
Img14	21.29	12.64	15.22	15.61
Img15	22.99	11.27	9.46	13.60
Img16	21.10	16.94	18.66	18.93

The proposed work has been compared with visushrink ,edge smoothing filter and optimized filter. From the results it has been observed that proposed work produces promising results.

Conclusion:

In this paper new techniques have been proposed to reduce noise and to correct the background in a noisy microarray image. Results shows proposed algorithm produces promising output for both denoising and background correction. Proposed methods can be used as efficient preprocessing technique for the subsequent stages of microarray image analysis.

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