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Grey Level X-ray Image De-noising Using Singular Value Decomposition Method

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ABSTRACT: Research work is carried out to investigate the effectiveness of the SVD based technique to filter biomedical images. Different noise level images were taken and the image quality parameters such as PSNR, SNR, RMSE, and MAE were calculated with respect to original image. After subjecting to the algorithm the image quality parameter were calculated and compared to the noisy images parameters. It is observed from that the algorithm works effectively to filter the noisy images.

Keywords: SVD, noise, PSNR, MAE.

I. INTRODUCTION

Image filtering techniques are needed nowadays due to the massive production of digital images and movies. Generally these techniques are required due to the fact that often digital images are taken in poor conditions. In-order to extend the range of action of a camera, an improvement in image is always desirable. A digital is generally represented as matrix of grey level or RGB colour values [1-4]. A digital image in case of grey level images, *i* is a point on a 2D grid and *u(i)* is a real value. Colour images have triplet values of *u(i)* for red, green, and blue components. Blur and noise are two limitations in image accuracy. Image with noise added to it can be represented as

$$v(i) = u(i) + n(i)$$

where *v(i)* is the observed value, *u(i)* is the true pixel value at *i*, and *n(i)* is the noise perturbation.
Image de-noising is the operation of removing unwanted noise from a noise-corrupted image, restoring the image to its un-degraded ideal. SVD technique is implemented to de-noise the biomedical images. SVD can be computed as

$$A = U\Sigma V^T$$

$U^T U$ and $V^T V$ yields the identity matrix. Hence U and V are matrix of orthonormal columns. Σ matrix is a diagonal elements $\{\sigma_1, \sigma_2, \sigma_3, ..., \sigma_D\}$. The values of $\{\sigma_k\}_{k=1}^{D}$ are called singular values and having a decreasing order i.e. $\sigma_1 \geq \sigma_2 \geq \sigma_3 \geq .... \geq \sigma_D \geq 0$. SVD has a remarkable property of statistical representation of *A* in subspaces of decreasing importance. *A* can be reconstructed by setting all of the singular values to zero except σ_1. The resulting matrix has a rank of one. Also it can be proven that A_K, the rank-*K* approximation to *A* using only the first *K* singular values, is the closest rank-*K* matrix to *A*. After designing the algorithm images were subjected to evaluate the following image quality parameter described below

Root mean square error (RMSE) corresponds to pixels in the reference image and the fused image. If the reference image and fused image are alike give the RMSE value equal to zero and it will increase when the dissimilarity increases between the reference and fused image [10].

$$RMSE = \sqrt{\frac{1}{MN}\sum_{x=1}^{M}\sum_{y=1}^{N}(I_r(x,y) - I_f(x,y))^2}$$

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Peak signal to noise ratio (PSNR) value will be high when the fused and reference images are alike and higher value implies better fusion. PSNR is calculated by follow equation [11-12]

$$PSNR = 20\log_{10}\left(\frac{L^2}{\sqrt{\frac{1}{MN}\sum_{x=1}^{M}\sum_{y=1}^{N}(I_r(x,y)-I_f(x,y))^2}}\right)$$

Signal to noise ratio (SNR) is calculated using following [13]

$$SNR = 10\log_{10}\left(\frac{\sum_{x=1}^{M}\sum_{y=1}^{N}(I_r(x,y)-I_f(x,y))^2}{\sum_{x=1}^{M}\sum_{y=1}^{N}I_r(x,y)}\right)$$

II. METHODOLOGY

Research work is carried out design an algorithm based on SVD technique to de-noise the X-ray image of human hand. Figure 1 shows the block diagram of the schematic implemented to de-noise the image. An original input image in grey level was taken shown in Fig. 2. In order to obtain noisy image, a random signal with multiple of scalar quantity ranging from 10 to 30 with step size of 5 is added to the original image. The size of original image matrix and random noise signal matrix are of same size. After adding the noise in the image, various image quality parameter of the noisy image such as PSNR, SNR, RMSE, and MAE value were calculated with respect to original image. These values were kept for the comparative analysis between the noisy and filtered image. After subjecting the noisy image to the algorithm, the PSNR, SNR, RMSE, and MAE of the reconstructed image were calculated.

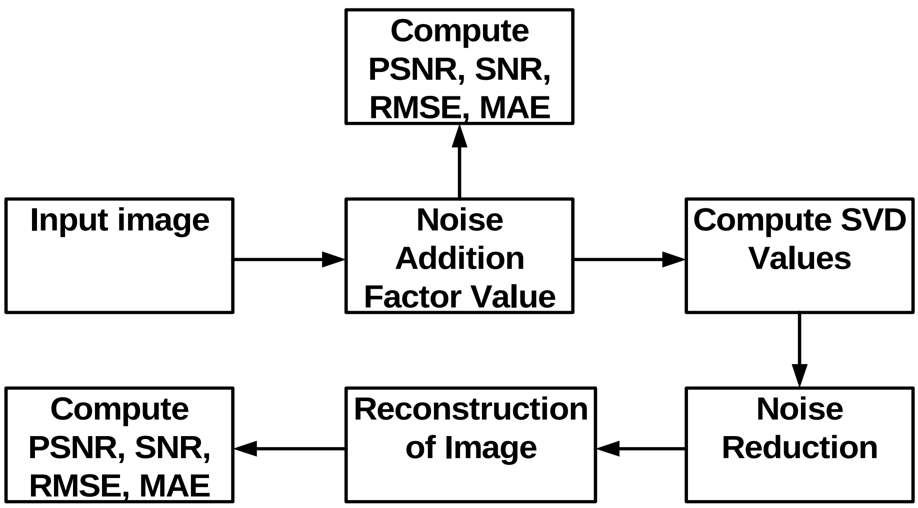

Fig. 1. Schematic of the design algorithm.

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Fig. 2 Original scanned X-ray image of the human hand.

III. Result and Discussion

Computer based algorithm to filter the noisy image employing SVD technique has been designed. Figure 3 shows the noisy images with increasing order of the noise level factor in first column and corresponding de-noised images in second column. Computed values of PSNR, SNR, RMSE, and MAE for noisy images and de-noised images with respect to original image are given in TABLE I and TABLE II respectively.

TABLE I
Computed value of noisy image parameter

Noise Level	Noisy Image			
	PSNR (dB)	SNR(dB)	RMSE	MAE
10	27.42	-0.00250	18.85	19.84
15	23.54	-0.00286	29.46	31.98
20	21.32	-0.00289	38.06	41.26
25	20.25	-0.00279	43.05	47.61
30	19.45	-0.00256	47.21	51.88

TABLE III
Computed value of De-noised image parameter

Noise Level	Noisy Image			
	PSNR (dB)	SNR(dB)	RMSE	MAE
10	33.82	-0.00342	9.02	10.21
15	33.92	-0.00140	8.92	8.45
20	32.34	-0.00087	10.70	10.87
25	31.62	-0.00043	11.63	11.36
30	30.53	-0.00092	13.18	13.18

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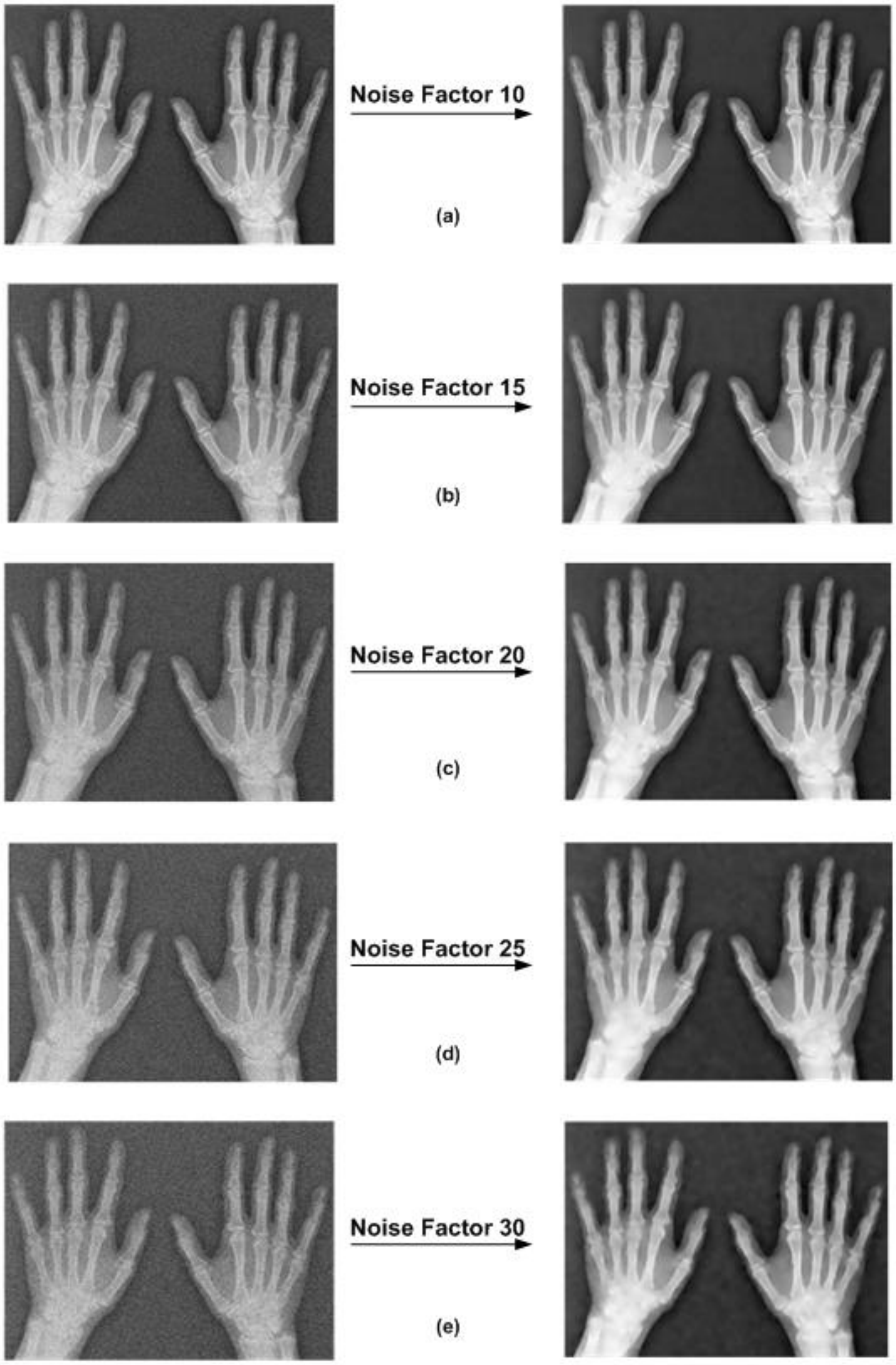

Fig. 3 noise level from 10 to 30 and corresponding de-noised image from (a) to (e).

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IV. CONCLUSION

Research work is carried out to design the computer based algorithm to filter noisy X-ray images. SVD based technique is implemented to filter the images. PSNR, SNR, RMSE, and MAE of the noisy image for lowest level are 27.42 dB, -0.00250 dB, 18.85, 19.84 and for highest level are 19.45, -0.00256, 47.21, 51.88 respectively. Similarly for de-noised image quality parameter for lowest level are 33.82 dB, -0.00342 dB, 9.02, 10.21 and for highest level are 30.53 dB, -0.00092 dB, 13.18, 13.18 respectively.

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