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Evaluation of SVD and DCT Models for Image Denoising

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***Abstract*—**The quality of digital image is degraded by many sources of noise such as imperfect instruments, interference from natural phenomena, transmission errors etc. Suppressing noise from these images is a challenging problem for the researchers. Lots of denoising techniques have been developed. Singular value decomposition (SVD) is one of the robust techniques in removing such noise from digital images In this research study, the presence of noise in digital images has been estimated and correspondingly removed using the proposed SVD technique. The results obtained have been comparatively analyzed using DCT technique of noise removal.

***Keywords*—**Tampering; singular value decomposition; DCT; gaussian noise; salt; pepper.

I. Introduction

Image denoising in digital image processing focuses on the removal of noise, which may disturb an image during its acquisition or transmission. The quality of these images is degraded by most common gaussian and salt and pepper noise. Salt and pepper noise can corrupt the images where the corrupted pixel takes either maximum or minimum gray level [1], [2]. The presence of noise in the image has two disadvantages, the first being the degradation of the image quality and the second, more important, obscures important information required for accurate processing of such images [3], [4]. Thus there is a great need of noise removal so that these digital images can be further used for deriving actual information. SVD is one of the robust techniques to remove noise from digital images. An application of SVD in image analysis shows considerable good results in handling different types of alterations. In this paper a SVD based noise removal technique has been used for detecting the presence of noise and removed accordingly. Further the results of noise removal have been compared with one of the existing technique of noise removal – Discrete Cosine Transform (DCT) to evaluate the extent of noise removal using the proposed technique. Section 2 represents different types of noise used for experimental analysis. The proposed technique and the methodology have been elaborated in Section 3. Section 4 represents the results and the analysis of the experimental study and conclusion is presented in Section 5 respectively.

II. Noise in Image

*A. Gaussian Noise***-** The standard model of amplifier noise is Gaussian, additive, free at each pixel and free of the signal intensity, caused mostly by thermal noise. In case where additional amplification is used, there can be more noise in the channel. Amplifier noise is a most important component of the read ise of an image sensor [12].

*B. Salt-and-Pepper Noise***-** Fat-tail distributed or impulsive noise is at times called spike noise or salt-and-pepper noise. An image containing salt-and-pepper noise will have dark pixels in bright regions and bright pixels in dark regions. This type of noise can be caused by convertor errors, bit errors in transmission, etc

C. Speckle Noise **-** Speckle noise is a multiplicative additional shot noise. This shot happens in pretty much all coherent imaging systems. Speckle noise has the characteristic of multiplicative noise and it obey distribution given as

$$f(g)=\left\{\frac{g^{a-1}}{(a-1)!a^{a}}\right\}e^{-\frac{g}{a}} \quad (1)$$

Where variance is a $\boldsymbol{2\alpha}$ and $\boldsymbol{g}$ is the gray level [13].

III. Related Work

P. Kamboj et al. (2013) [2] described that enhancement of a noisy image is necessary task in digital image processing. Filters are used best for removing noise from the images. Various types of noise models and filters techniques have been described. Filters techniques are divided into two parts linear and non-linear techniques. S. Vadivu et al. (2012) [3] proposed a filter which is more effective in restoring the images corrupted with fixed value impulse noise. Since it is computationally simple, the restoration rate is faster. This filter finds application in eliminating noise from various scanning images, used in the study of surface morphology, because these images are invariably degraded by fixed value impulse noise. SVD based noise removal method called SVD-TR has been proposed by D. Sharma et al. The experimental results show a large extent of noise removal from digital images (2014) [4]. V. Jayaraj et al. (2010) [6] describes the new method which introduces the concept of substitution of noisy pixels by linear prediction prior to estimation. A novel simplified linear predictor is developed for this purpose. The objective of the scheme and algorithm is the removal of high-density salt and pepper noise in images. K. Aiswarya et al. (2010) [7] described a new algorithm to remove high-density salt and pepper noise using modified sheer sorting method. The algorithm has lower computation time as compared to other standard algorithms. Results of the algorithm are compared with various existing algorithms and

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it is proved that the new method has better visual appearance and quantitative measures at higher noise densities. G. Ilango et al. (2011) [8] introduced various hybrid filtering techniques for removal of Gaussian noise from medical images. The performance of Gaussian noise removing hybrid filtering techniques is measured using quantitative performance measures such as RMSE and PSNR. The experimental results indicate that the Hybrid Max Filter performs significantly better than many other existing techniques. The method is simple and easy to implement.

P. E. Ng et al. (2006) [9] proposed a novel switching median filter incorporating with a powerful impulse noise detection method for effectively denoising extremely corrupted images. To determine whether the current pixel is corrupted, the algorithm first classifies the pixels of a localized window, centering on the current pixel, into three groups- lower intensity impulse noise, uncorrupted pixels, and higher intensity impulse noise. Z. Afrose (2012) [10] described a method to remove Salt & pepper, Gaussian and Speckle noise from compound images using median filter, relaxed median filter, wiener, centre weighted median and averaging filter. The performance of the different filters with the applied noises using compound images are compared and analyzed according to PSNR value.

The SVD based noise removal model has been proposed for noise estimation and its removal. This research study has been undertaken with the objectives of proposed a SVD based noise removal model, identification and implementation of proposed model of Noise removal using standard noise and comparative analysis of SVD based Noise Removal technique with Discrete Cosine Transform (DCT).

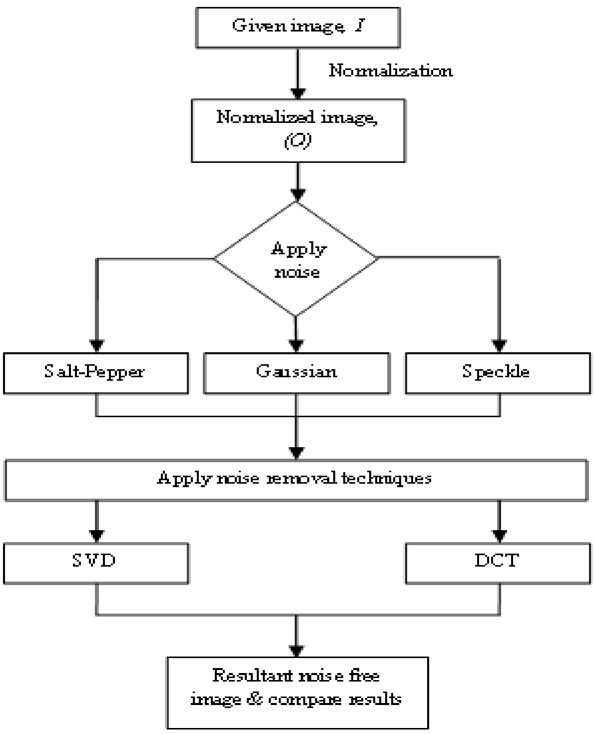

Fig. 1. Schematic Workflow of the proposed study.

IV. PROPOSED SVD TECHNIQUE FOR NOISE REMOVAL

In this research study, SVD based noise detection and removal method is proposed which helps in generating efficient results for noise free image. The main goal of our research study is to generate a denoised image using the proposed technique of noise removal.

For evaluating the efficiency of the proposed model three type of noise- salt-pepper, speckle and gaussian noise have been added to the given input image. More than 150 test images taken from different standard medical image database, *DB[i]* for experimental analysis. The proposed SVD based model is applied to the given set of tampered images. In this proposed technique of noise removal, noise has been removed from images taken from medical database [15]. The test images and corresponding noisy images have been shown in fig 2.

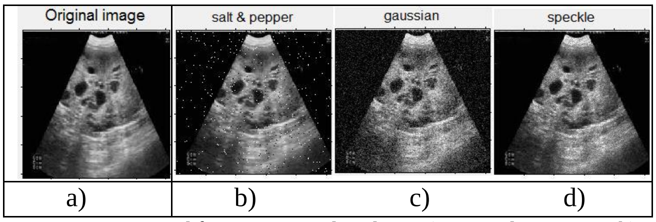

Fig. 2. Test image used for experimental analysis. a) Original test image, b), c) and d) image obtained after adding noise (salt-pepper, Gaussian and speckle noise respectively)

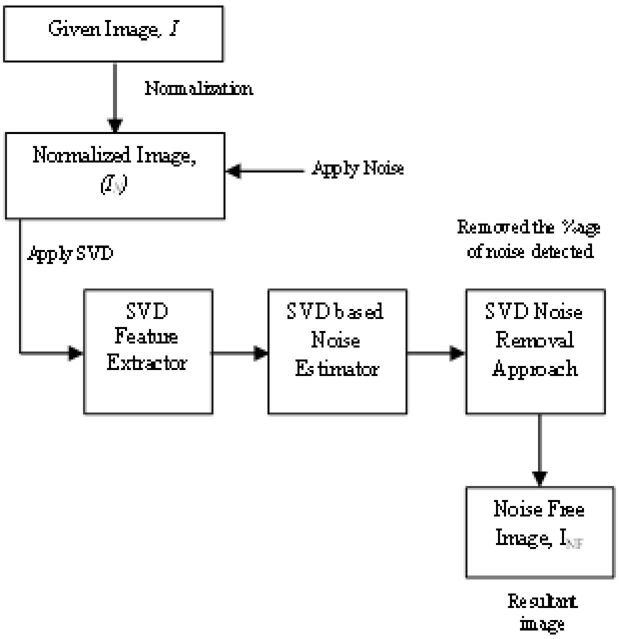

Fig. 3. Schematic diagram showing the work flow of proposed SVD based noise removal technique.

A. Noise Estimation and Removal through SVD

SVD based noise estimation and removal model has been proposed as shown in Fig 3.

The model describes the concept and workflow of proposed SVD technique of noise removal. This proposed system takes the original image from the database as input and after processing generates the corresponding noise free images.

Image, **I** has been taken from the set of selected database of medical images as input to the proposed system. ***I*** has been normalized in required format to obtain normalized image, I_N for further processing. For testing the proposed model, selected noise has been added to the input image, ***I.*** After adding noise, SVD has been applied to I_N in order to extract the basic features of digital image, which has been used for further testing. The proposed SVD based noise estimation and removal model has been applied to I_N to estimate the presence of noise. A resultant noise free image (I_{NF}) has been generated. This resultant noise free image (I_{NF}) has been compared with the corresponding original input image, ***I*** to calculate the extent of noise removal and image match.

B. DCT Based Noise Removal

The algorithm of removing noise from digital images using the standard DCT technique involves the following steps:-

1. Take the input image from the database.
2. Divide image into overlapping blocks
3. Apply DCT
4. Sort the rows lexicographically
5. Discard offset values greater than threshold.
6. Calculate the noisy pixels of the image
7. Apply 2D-DCT, threshold, u, the DCT coefficients.
8. Obtain the denoised image.

By applying DCT Noise removal model, the denoised image is generated [15].

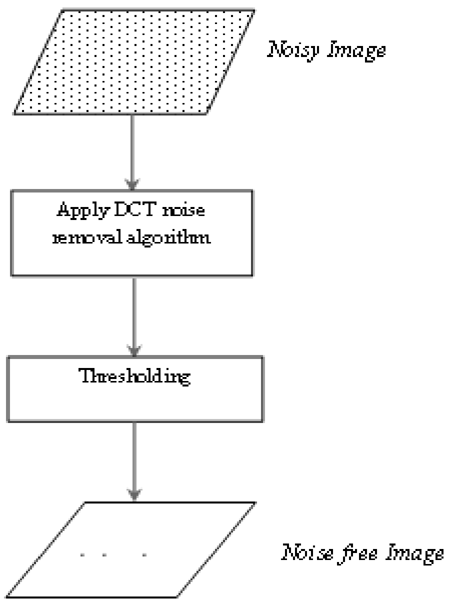

Fig. 4. Flow diagram for DCT based noise removal algorithm.

The corresponding results of the proposed algorithm of SVD and the DCT based noise removal model have been presented in the next section. The experiments are performed using Matlab interface on a 32-bit machine with a processor speed of 3.2 GHz using 1GB of DDR2 RAM. All images are converted into grayscale with image size- 150 x 150 and .bmp format.

V. Result Analysis

SVD based noise removal model has been applied to different test images in removing three different types of noise and obtain the corresponding denoised images. These three noise types have been also removed using DCT. The results obtained after noise removal from the noisy images have been shown below.

Table 1 shows the results obtained from the proposed SVD based Noise removal model and the noise removed by the existing method of noise removal – DCT.

Table 1. SVD and DCT based noise removal methods using different standard noises (in %age).

Image	Salt pepper		Gaussian		Speckle	
	SVD	DCT	SVD	DCT	SVD	DCT
I_1	67.45	38.54	71.82	45.92	73.14	42.84
I_2	68.23	30.19	69.21	50.21	68.73	38.54
I_3	70.94	49.39	73.98	49.22	76.02	44.62
I_4	78.21	45.22	77.99	50.22	73.91	45.73
I_5	63.01	38.42	64.92	43.82	69.34	39.82
I_6	64.92	33.94	67.29	39.89	69.65	53.92
I_7	74.81	39.12	77.28	46.92	70.29	55.92
I_8	75.04	40.22	74.82	37.92	65.82	40.24
I_9	69.11	43.72	69.84	41.92	71.64	49.73
I_{10}	78.23	44.82	77.27	53.92	73.84	56.92

The results obtained are shown in percentage. The analysis of the results is shown in Fig. 5.

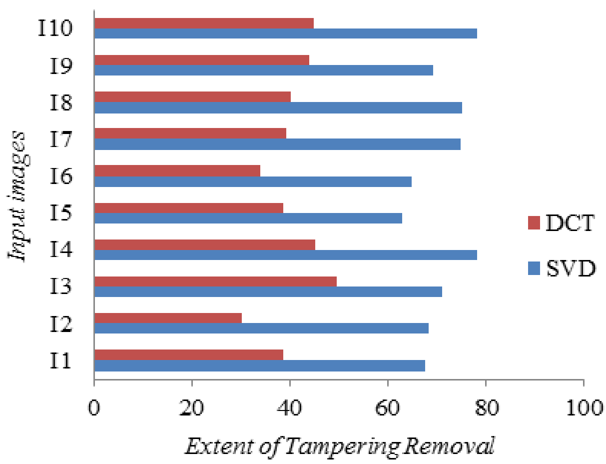

Fig. 5. Salt-Pepper noise removal using SVD and DCT.

The analysis of the results obtained after removing noise from the input images has been shown in Fig 5. The graphs depicts that the proposed SVD based noise removal model

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comparatively shows good results in the removal process of salt-pepper noise as compared with the DCT method.

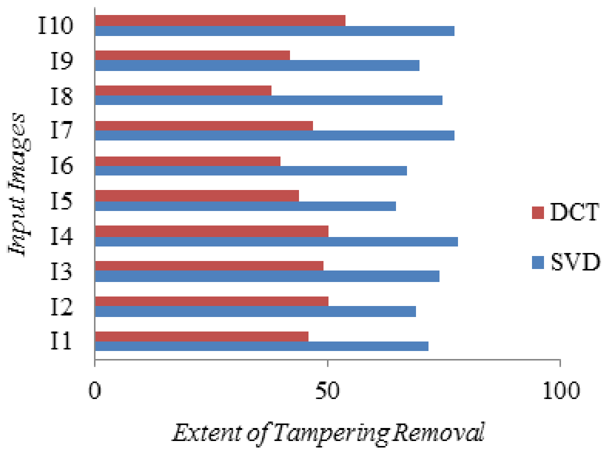

Fig. 6. Gaussian noise removal using SVD and DCT.

The analysis of the experimental results has been shown in Fig. 6. It is evident from the graph that the percentage of noise removal from digital input images using the proposed SVD based noise removal model are greater than the results obtained using DCT.

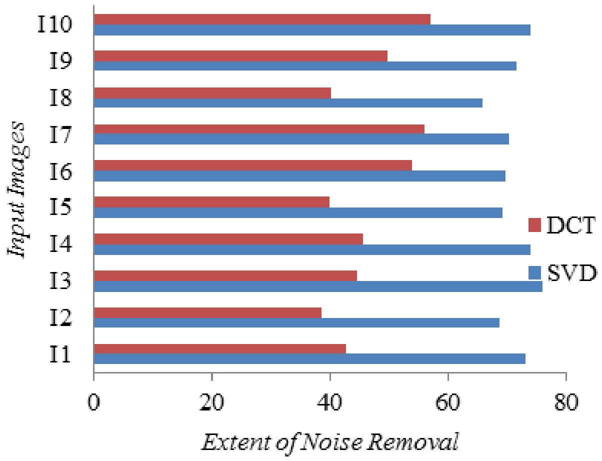

Fig. 7. Speckle Noise Removal using SVD and DCT.

Another type of noise - Speckle noise has been removed using the proposed model and the DCT model of noise removal. The results of the extent of tampering removal have been analyzed as shown in Fig 7. The results indicates that the proposed model removes noise efficiently as the extent of noise removal is maximum as compared with the results obtained using the DCT model of noise removal.

VI. Conclusion

In this research study, different types of noise have been introduced in the input images to test the proposed model. The proposed SVD model removes noise by extracting basic features of the images whereas the DCT technique removes noise by dividing the noisy input image in blocks The comparative analysis thus indicate that the proposed SVD based noise removal model considerably shows consistent and at times better results of denoising in these three types of noise removal.. It is evident that the SVD can work better in removing noise from the digital images as compared with the DCT. In future SVD shall be applied to more complex image database for removing different manipulations or tampering from digital images. Image feature based image comparison shall be done for different images.

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