Applications of Kekre's Wavelet, LPG_SVD_ST_W, LPG_PCA_ST_W, Don't Care Filter for Blind Image Restoration of Corona CT, Fingerprint and Vegetation Images

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***Abstract*—Kekre's wavelet, LPG_SVD, LBG_PCA_ST_W, LBG_SVD_ST_W, Don't care filter are fast image denoising techniques. Image denoising is prerequisite for many applications to run smoothly and need to be fast, so application of these techniques are analyzed for practical applications such as CT images of corona patient, finger print images and vegetation images by using subjective and objective evaluation in this paper. It is found that don't care filter has given better performance as compared to other methods. The PSNR is increased by 10% as compared to noisy images for vegetation images with minimum amount of time 1.2 seconds on an average.**

***Index Terms*—Kekre's Wavelet, LBG_PCA_ST_W, LBG_SVD_ST_W, LPG-SVD, Don't care filter, Corona CT, Fingerprint, vegetation**

I. INTRODUCTION

Kekre's wavelet [1], LPG_SVD [2], LBG_PCA_ST_W [3], LBG_SVD_ST_W [3], Don't care filter [4] techniques are recently developed fast denoising techniques. Image denoising and image deblurring are generally used as pre-processing tools, hence it is necessity that these techniques must be very fast and should not cause much overload. As these techniques serve this purpose, we are analyzing their practical application on medical CT images of Corona Patient, finger print images [5] and vegetation images which we collected from internet.

These methods are already compared by using objective criteria PSNR and SSIM, in literature [1], [2], [3],[4] and proved to give improved results.

Many practical applications do not have original noise free image for comparison, so for blind image denoising the blind quality metrics can be used but it is proved in literature that these metrics are not as good as non blind metrics Peak signal to noise ratio (PSNR) and Structural Similarity Index Measure (SSIM) [6]. As these techniques are already compared using PSNR and SSIM, here we are evaluating the resultant images by using subjective criteria wherever original image is not available and by objective criteria for vegetation images as original images are available. Ultimately images are visual contents and subjective evaluation is important for practical applications.

II. METHODOLOGY

A. Kekre's Wavelet

Kekre's wavelet is new wavelet [7] which has proved better than Haar in many applications. Therefore its performance is checked for image denoising in the paper [1] and in this paper the performance is tested for practical applications.

B. LBG_SVD_ST_W, LBG_PCA_ST_W

These techniques applied LBG followed by PCA / SVD [8] and soft thresholding [9] and Wiener filtering for image denoising. These techniques have combined advantages of Vector quantization and PCA/SVD de-correlating techniques for image denoising.

C. Don't Care Filter

This filter has reduced the number of pixels to near about half than any other filters such as averaging, median and reduced complexity to half. In this paper its performance is tested for practical applications.

III. RESULTS AND ANALYSIS

The above mentioned techniques are tested for 2 corona affected CT scan images of patients, 3 finger print images and 6 vegetation color images. As an example results of corona CT images are shown in Figure 1 and results of finger print images are shown in Figure 2. For corona images and finger print images, original images are not available so time required to execute is compared in Table 1.

Observations:

It is observed from Table I that time required to execute is least by don't care filter followed by Kekre's wavelet and then LBG-PCA-ST-W and LBG-SVD-ST-W took maximum time to execute but this time is also less if compared with advanced techniques like LPG-PCA [8].

Observations:

It is observed from Fig. 1 that noise is reduced by all the methods but little blurring effect is also there. Don't care filter reduced noise little but edges are not blurred by it.

It is observed from Fig. 2 that all the techniques have reduced noise and preserved important information. Don't care filter have more dark lines as compared to other methods.

LPG-SVD [2] is also used for corona CT images, but for execution of images used here the method took more than an hour to execute, so not useful here for this practical application. Therefore it is not included in further discussion.

TABLE I. TIME TAKEN TO EXECUTE FOR CT AND FINGER PRINT IMAGES

Technique \ Images	Kekre's wavelet	LBG-PCA-ST-W	LBG-SVD-ST-W	Don't care Filter
Corona 2	8.03	75.11	130.8	4.5
Corona 3	19.33	72.74	124.57	4.61
Finger	17.30	19.54	39.768	1.96
Finger 2	21.01	15.95	25.43	1.79
Finger 3	8.088	14.19	26.15	1.63
Average	14.75	39.51	69.34	2.9

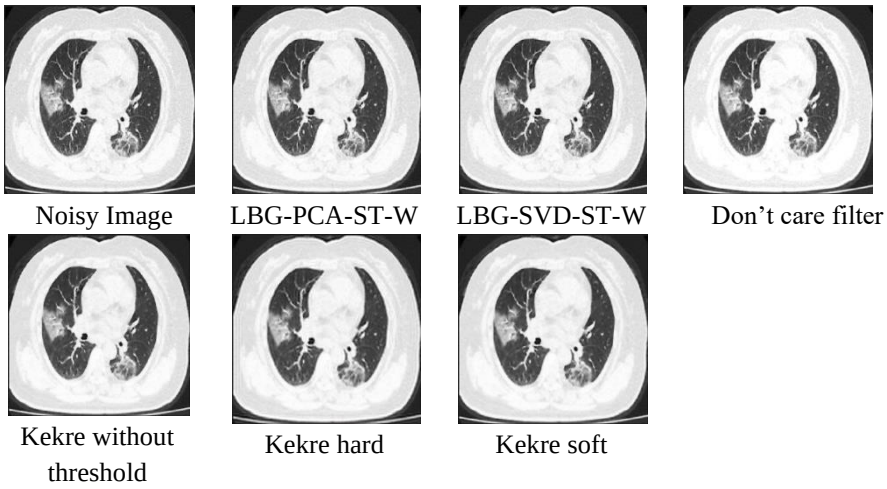
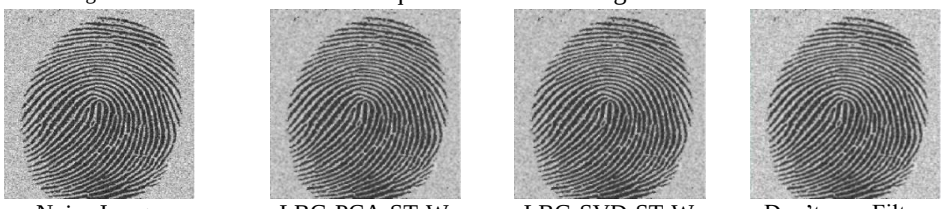


Fig. 1. The results of all techniques on CT scan images of Corona Patient




Kekre without threshold


Kekre hard


Kekre soft

Fig. 2. The results of all techniques on finger print images

These techniques are also tested for 6 colour vegetation images. For vegetation images the original images were available so techniques are compared based on PSNR, SSIM and time to execute.

Table II, Table III and Table IV compares PSNR , SSIM [6] and time to execute for 6 vegetation images. As an example the resultant images are shown for 2 vegetation images in Fig. 3 and Fig 4 respectively.

TABLE II. PSNR FOR ALL TECHNIQUES BY VEGETATION IMAGES

Technique \ Images	Noisy	Kekre's Wavelet without thresholding	Kekre's Wavelet with hard thresholding	Kekre's Wavelet with soft thresholding	LBG-PCA-ST-W	LBG-SVD-ST-W	Don't care Filter
Veg 1	29.31	30.12	29.82	30.08	30.13	30.14	32.44
Veg 2	29.31	29.63	29.40	29.58	29.50	29.50	31.55
Veg 3	29.30	30.18	29.93	30.16	30.11	30.07	32.18
Veg 4	29.3	30.51	30.25	30.50	30.78	30.81	32.06
Veg 5	29.329	30.03	29.78	30.02	29.98	29.98	31.83
Veg 6	29.312	31.55	31.43	31.67	32.27	32.24	33.03
Average	29.31	30.34	30.10	30.33	30.46	30.46	32.18

Observations

It is observed from Table II that all the techniques have improved PSNR as compared to noisy images. Maximum PSNR is obtained by Don't care filter. The PSNR is increased by 10 % as compared to noisy image by don't care filter.

TABLE III. SSIM FOR ALL TECHNIQUES BY VEGETATION IMAGES

Technique \ Images	Noisy	Kekre's Wavelet without thresholding	Kekre's Wavelet with hard thresholding	Kekre's Wavelet with soft thresholding	LBG-PCA-ST-W	LBG-SVD-ST-W	Don't care Filter
Veg 1	0.75	0.69	0.62	0.68	0.73	0.73	0.80
Veg 2	0.72	0.57	0.50	0.55	0.49	0.50	0.60
Veg 3	0.67	0.62	0.56	0.60	0.56	0.56	0.64
Veg 4	0.69	0.63	0.57	0.62	0.62	0.61	0.60
Veg 5	0.66	0.54	0.49	0.53	0.49	0.49	0.58
Veg 6	0.54	0.67	0.64	0.67	0.69	0.69	0.64
Average	0.67	0.62	0.56	0.61	0.60	0.60	0.64

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TABLE IV. TIME TO EXECUTE (IN SECONDS) BY ALL TECHNIQUES FOR VEGETATION IMAGES

Technique \ Images	LBG-PCA-ST-W	LBG-SVD-ST-W	Don't care Filter	Kekre's wavelet
Veg 1	69.4	123.2	1.6	12.60
Veg 2	13.5	26.3	1.0	7.79
Veg 3	14.3	26.5	1.2	7.63
Veg 4	13.8	26.1	1.2	7.89
Veg 5	13.7	26.0	1.3	8.13
Veg 6	13.8	26.3	1.1	8.21
Average	23.1	42.4	1.2	8.71

Observations

It is observed from Table III that all the methods reduced SSIM than noisy image but still this reduction is less by don't care filter.

Observations

It is observed from Table IV that all the techniques are fast but as compared to all don't care filter is fastest. The time to execute is hardly one second only.

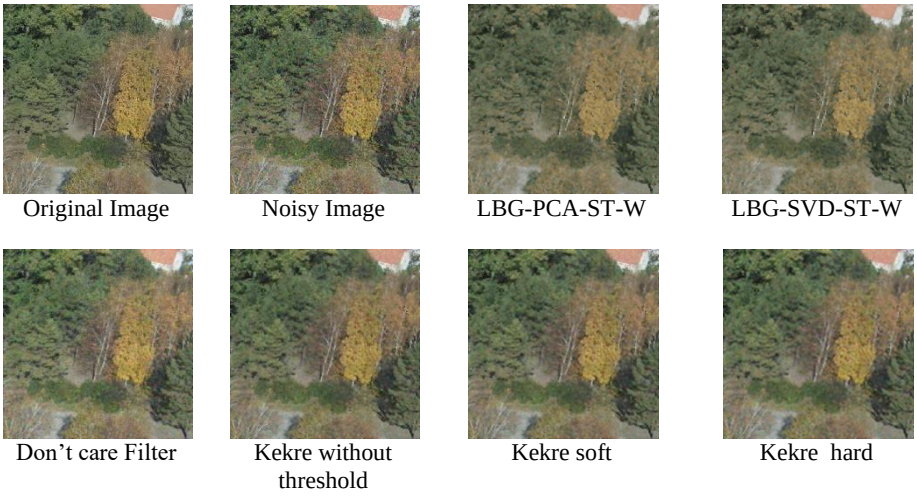

Fig. 3. The results of all techniques on Vegetation image 1

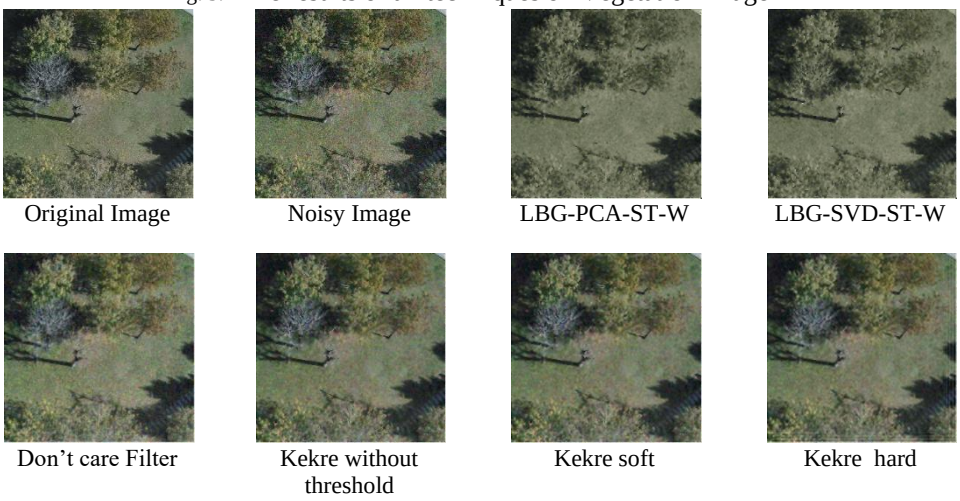

Fig. 4. The results of all techniques on on Vegetation image 2

Observations

It is observed from Fig. III and Fig. IV that all techniques have reduced noise but LBG_PCA_ST_W and LBG_SVD_ST_W techniques have blurred the image more as compared to other techniques. Colours are also averaged by these two techniques. The main reason can be these vegetation images are textured in nature, so these techniques are not able to perform well with textured images.

IV. CONCLUSIONS

In this paper Kekre's wavelet, LBG_PCA_ST_W, LBG_SVD_ST_W, Don't care filter techniques are applied on practical applications such as CT images of corona patient, finger print images and vegetation images. These techniques are evaluated by using subjective and objective evaluation. It is found that don't care filter has given better performance as compared to other methods. The PSNR is increased by 10% as compared to noisy images for vegetation images with minimum amount of time 1.2 seconds on an average. For textured images like vegetation the techniques denoised the images but still the performance can be improved for them.

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