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De-noising of PV Thermal Image by using Wavelet Transform

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Abstract: ***In this paper we focused on removal of noise in thermal image. Thermal image is a technique to improve the visibility of object in dark environment. Thermal imaging camera is a device that captures the image of the object and displayed on its screen. Noise in thermal image is for predicting the performance of thermal image system. Noisy images are found in many imaging application. Image acquisition and image transmission are the noise sources. De-noising of images is most important task in image processing. Linear as well as non-linear methods can be done in de-noising. Filtering can be used for removing of noise in the image. For that we use DWT method as an algorithm. The reconstructed image quality can be measured by the parameters such as SNR, PSNR, MSE, and SSIM.***

Index Terms: Noising, De-noising, Filtering, DWT Wavelet

I. INTRODUCTION

Thermal Image collects the IR radiation from an object and creates an electronic image. It is developed for military purposes in 1950s and 1960s by Texas instruments, Honeywell and Hughes Aircraft. In recent thermal imaging is used in industrial, medical, security, transport and many other applications. Thermal image can penetrate many obscurants such as fog, smoke and haze. Through thermal cameras many users can identify objects in different temperatures which are helped by adding colors to images. Thermal camera captures the images and records the current signatures of the devices. The range of thermal camera is approximately -50°C over 2000°C. The cooled thermal imager and un-cooled thermal imager are the types of thermal imaging cameras. Cooled thermal imager is very expensive to produce and run. Un-cooled thermal imager is less cost to produce and run.

The main advantages of thermal imaging is that to measure the subject in areas hazardous for other methods and it has capability of catching movable object in real time and low light conditions. It helps in fault detection in image. It helps to identify air leakages and possible irregularities in insulation. Thermal cameras can easily install and perform at a convenient time and it can easily see all objects at dark environment. Solar Energy is produced from the Photovoltaic panel which can be also known as PV panel, which has the major attention in the environment as one of the promising renewable resources. The radiated energy collected through the photovoltaic panel is installed in the outdoors. The photovoltaic panel can be affected by wind, salt, snow and dust that may the factors such as short circuit, corrosion and efficiency of generating power from solar panel. The regular fault diagnosis, repair and constant maintenance increase the efficiency of PV panel and maintain the stable performance. This method will be helpful to consume time in maintaining large scale PV power plant. To diagnosis the defect occurred in the PV panel, the images are captured from the thermal camera where the temperature changes can be noticed and the faults can be analyzed.

The failure of the solar panel can be noticed by comparing the normal solar panel and thermal images. Image de-noising is the process of removing noise from images. [5] Thermal noise is caused by random movement of electrons due to thermal energy that is proportional to temperature.

Hereby we can able to notify the errors in the photovoltaic panel by using the noising and de-noising. In this paper, section II describes the DWT methodology, section III describes implementation results and section IV ends with conclusion.

II. METHODOLOGY

Wavelet is mathematical requirement for representing data. [8] At recent times, JPEG committee released JPEG 2000. This Image coding standard is based upon Discrete Wavelet. Fig. 1 shows the 3 level DWT architecture for image filtering which consists of both analysis and synthesis section. The DWT has introduced high efficient sub band decomposition of signal. Wavelet can store more efficient than pixel box. The Wavelet transforms decomposes the signal into set of basic functions are called wavelets. There is no certain wavelet to choose. Different types of wavelets are Haar, Daubechies, Morlet, Biorthogonal, Symlets, Mexican Hat. [6] DWT transforms a DT signal into discrete wavelet representation. The representation of digital image is obtained by digital filtering techniques. Image consists of pixel that can be arranged in 2-D matrices.

Time-frequency representation of a signal can be providing by the wavelet transform.

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Wavelet can be classified by two methods: Orthogonal and bi orthogonal. In orthogonal the low pass and high pass filter has same length and in bi orthogonal the low pass and high pass filter do not have same length. One of the features of JPEG 2000 standard is used for 2D-DWT to convert the sample image into compressible form. Nowadays 2D-DWT is a key operation in image processing. [7]

The key problems in DWT are signal breakdown. The basic idea behind breakdown is low-pass filtering with the use of down sampling. [6] db4 Wavelet gives details more accurately than others. [6] db4 wavelet transforms are very similar. It is as same as the Haar wavelet transform. It can extend to multiple levels like Haar wavelet transform.

The sym wavelet than forms an orthogonal basis which we use to decompose signal. Sym wavelet is families of wavelets. This is modified version of Daubechies wavelets with increased symmetry. The sym wavelet transform is used for computing wavelet coefficient.

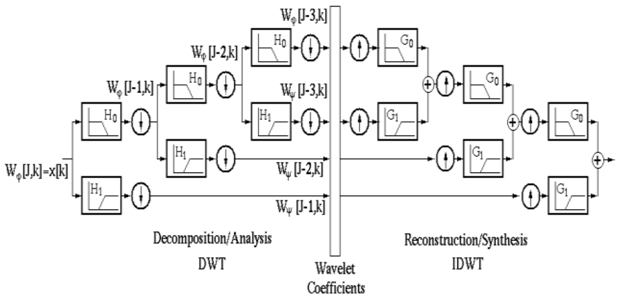

Fig. 1 Level DWT Archeitecture

III. IMPLEMENTATION AND RESULT

The parameters used are SNR, PSNR, MSE and SSIM.

A. SNR

The SNR is used to describe the performance of an instrument or quality of analytical method. It can enhanced by hardware or software techniques .SNR is calculated by dividing the value of main signal by the value of noise and then take common log of the result.

B. PSNR

The PSNR block computes between two images. The unit of PSNR is decibels. The original and a compressed image can be used as a quality measurement. The higher PSNR is the better quality of compressed or reconstructed image.

C. MSE

The MSE is the cumulative squared error between the compressed and original image. The various image compressor techniques are the MSE and PSNR.

Equation (1) and (2) shows the mathematical expression of MSE and PSNR respectively.

$$MSE = \frac{1}{MN} \sum_{Y=1}^{M} \sum_{x=1}^{N} [I(x, y) - I'(x, y)]^2 \quad (1)$$

$$PSNR = 20 * \log10 (255/\sqrt{(MSE)}) \quad (2)$$

where I(x, y) represented as original image,
I'(x, y) represented as approximated version,
M, N represented as dimensions of images.

A lower value for MSE means lesser error, the inverse relation between the MSE and PSNR which translates to the higher value of PSNR. A higher value of PSNR is considered as good parameter because the SNR is higher.

D. SSIM index

The SSIM index is used to measure the similarities between the two images. It is a full reference metric based on an initial uncompressed image is processed by the measurement or prediction of image quality.

Fig. 2 (a), (b), (c), (d) and (e) show the noised image 5 different PV panel thermal images. The random noise is added to every image to form the noised image. Fig. 3 (a), (b), (c), (d) and (e) show the denoised image 5 different PV panel thermal images. The denoising images are produced by the 3 level DWT. The db4 and sym2 wavelet are used to derive the lowpass and highpass wavelet filters in the DWT. Table 1 represents the parameter analysis of DWT based image filtering by using db4 wavelet. Similarly Table 2 represents the parameter analysis of DWT based image filtering by utilizing the sym2 wavelet.

Fig. 4 shows the SNR comparison of db4 and sym2 wavelets. Fig. 5 shows the PSNR comparison of db4 and sym2 wavelets. Fig. 6 shows the MSE comparison of db4 and sym2 wavelets. Fig. 7 shows the SSIM comparison of db4 and sym2 wavelets.

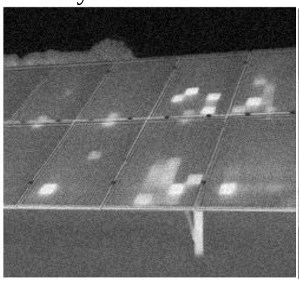

Fig. 2(a)

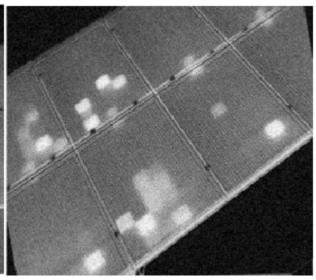

Fig.2(b)

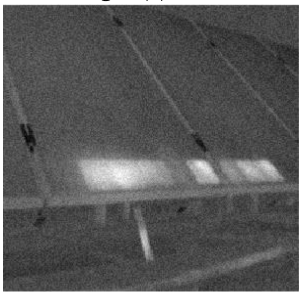

Fig. 2(c)

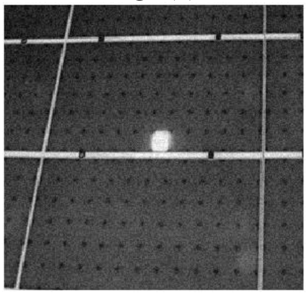

Fig. 2(d)

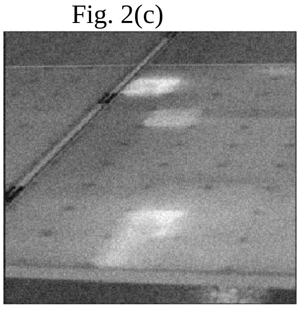

Fig. 2(e)

Noised PV panel Thermal Images

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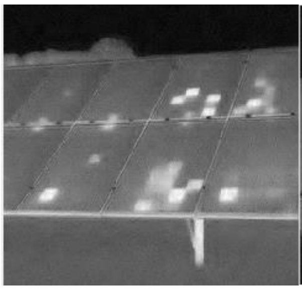

Fig. 3(a)

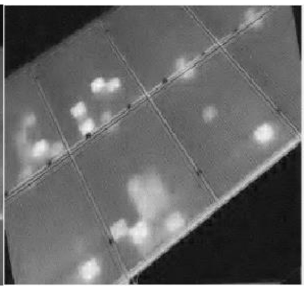

Fig. 3(b)

Fig. 3(c)

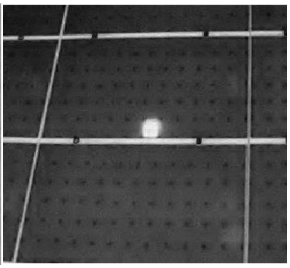

Fig. 3(d)

Fig. 3(e)

De Noised PV panel Thermal Images

Table 1 Parameter analysis of DWT based Image Filtering using "db4" wavelet

Thermal Images	SNR	PSNR	MSE	SSIM
Image 1	28.5152	-19.6156	91.5287	0.5701
Image 2	27.4242	-20.7067	117.6699	0.5725
Image 3	29.0487	-19.0821	80.9489	0.5532
Image 4	28.5489	-19.5819	90.8209	0.5815
Image 5	28.7136	-19.4172	87.4422	0.5573

Table 2 Parameter analysis of DWT based Image Filtering using "sym2" wavelet

Thermal Image	SNR	PSNR	MSE	SSIM
Image 1	28.5152	-19.6156	91.5287	0.5701
Image 2	27.4683	-20.6625	116.4808	0.5773
Image 3	29.0756	-19.0552	80.4486	0.5565
Image 4	28.5236	-19.6072	91.3527	0.5750
Image 5	28.7522	-19.3786	86.6676	0.5598

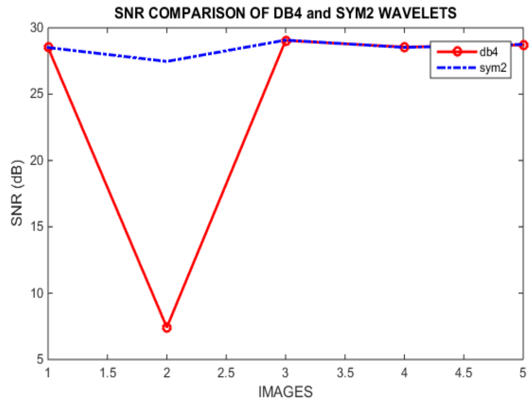

Fig. 4 SNR Comparison of db4 and sym2 wavelets

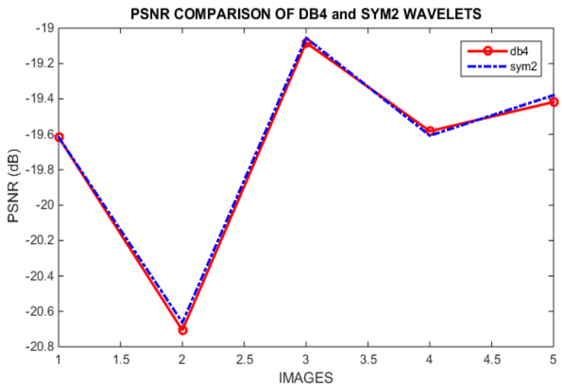

Fig. 5 PSNR Comparison of db4 and sym2 wavelets

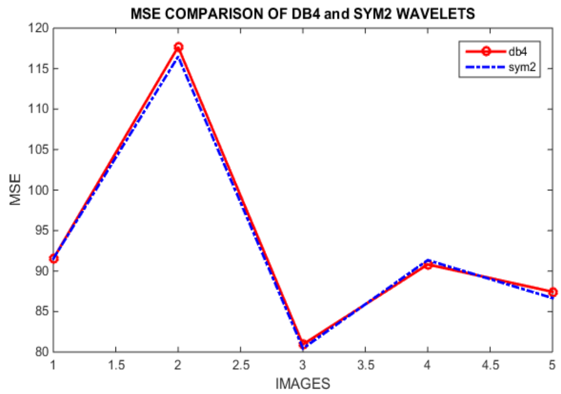

Fig. 6 MSE Comparison of db4 and sym2 wavelets

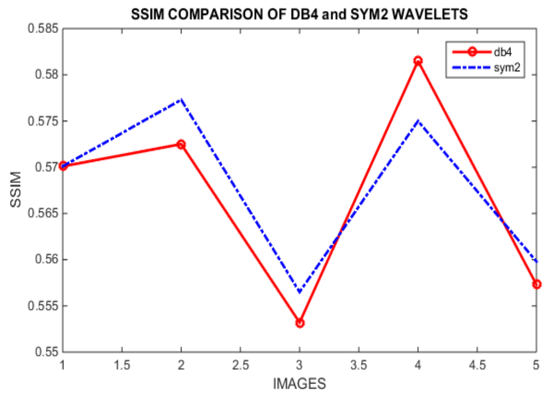

Fig. 7 SSIM Comparison of db4 and sym2 wavelet

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IV. CONCLUSION

We develop an algorithm for detecting a noise in PV panel based on wavelet transform. The parameters for noise detection are SNR, PSNR, MSE and SSIM. In comparison with all the parameters we applied, the SSIM index is designed to improve on traditional method such as PSNR and MSE. If the value of SSIM is higher, then the image is considered to reconstruct perfectly. These algorithms were implemented in five thermal images. Such sample images were of similar panel sizes and intensity characteristics. As we compare db4 and sym2 wavelets, there is only slight variation in the parameters. Even though the variation occurred, there won't be any changes in the wavelets, where the db4 and sym2 wavelets perform the filtering process with same level of accuracy.

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