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False Alarm Based Quasi Periodic Noise Removal in Digital Images

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Abstract— In general noise is random is nature and can be removed using both static and adaptive filters. Images may be affected by quasi-periodic noise. This artefact is often caused by electrical interferences during image acquisition or transmission, which makes remote sensing applications especially prone to the phenomenon. Periodic noise gives more or less sharp spikes in the image spectrum, which can be filtered out using notch filters. The difficulty is to automate spike detection, that is, notch filter design. Some authors suggest detecting spikes in the Fourier domain as large deviations with respect to a localized median value. However, distinguishing between spikes caused by a localized texture or a repetitive structure (common in man-made environments) and spurious ones caused by periodic noise is still challenging. It has been observed in past that periodic noise is likely to be the only periodic structure present in any patch extracted from the impaired image. The quasi periodic noise changes in structure over the time, thus removal becomes more complex. In this work, an algorithm is detailed for the design of notch filter, which is capable of suppressing quasi periodic noise.

Keywords— Noise, PSNR, Quasi-Periodic

I. INTRODUCTION

In general noise is random is nature and can be removed using both static and adaptive filters. Images may be affected by quasi-periodic noise. This artefact is often caused by electrical interferences during image acquisition or transmission, which makes remote sensing applications especially prone to the phenomenon. Periodic noise gives more or less sharp spikes in the image spectrum, which can be filtered out using notch filters. The difficulty is to automate spike detection, that is, notch filter design. Some authors suggest to detect spikes in the Fourier domain as large deviations with respect to a localized median value.

However, distinguishing between spikes caused by a localized texture or a repetitive structure (common in man-made environments) and spurious ones caused by periodic noise is still challenging. It has been observed in past that periodic noise is likely to be the only periodic structure present in any patch extracted from the impaired image. The quasi periodic noise changes in structure over the time, thus removal becomes more complex.

II. NOISE FILTERING PROCESS

Filtering techniques in the frequency domain are based on modifying the Fourier transform to achieve a specific objective and then computing the inverse DFT to get information back to the spatial domain [1,2]. If *b* is an image, then its Fourier transform will reflect the frequencies of the periodic parts of the image. By masking or filtering out the unwanted frequencies one can obtained a new image by applying the inverse Fourier transformation. A filter is a matrix with the same dimension as the Fourier transform of the padded image. The components of the filter usually vary from 0 to 1. If the component is 1, then the frequency is allowed to pass; if the component is 0, then the frequency is tossed out.

The form of the filter function determines the effects of the operator. There are basically three different kinds of filters: low pass, high pass and band pass filters. A low-pass filter attenuates high frequencies and retains low frequencies unchanged. The result in the spatial domain is equivalent to that of a smoothing filter; as the blocked high frequencies correspond to sharp intensity changes, i.e. to the fine-scale details and noise in the spatial domain image. A high pass filter, on the other hand, yields edge enhancement or edge detection in the spatial domain, because edges contain many high frequencies. Areas of rather constant gray level consist of mainly low frequencies and are therefore suppressed.

A band pass attenuates very low and very high frequencies, but retains a middle range band of frequencies. Band pass filtering can be used to enhance edges (suppressing low frequencies) while reducing the noise at the same time (attenuating high frequencies). Moreover, transform domain techniques are capable of removing some part of the noises. That is why in image enhancement DFT or FFT is used.

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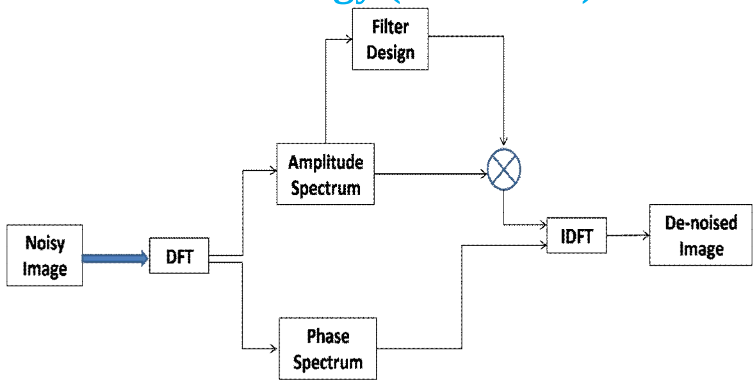

Fig. 1 Methodology for periodic noise removal process

A. Methodology for Periodic Noise Removal

The periodic noise methodology consists of the following sequence of steps:

Step1: Acquire the color image, apply direct conversion to convert color image to gray image and save the red and green components to be used later on in indirect conversion.

Step2: Transfer the gray image representation from time domain to frequency domain by applying 2D FFT which gives us the magnitude and angle matrix of the image, save the angle matrix to be used later on.

Step3:Analyze the magnitude matrix spectrum and prepare the filter mask.

Step 4: Correlate the magnitude matrix with filter mask.

Step 5: Use the correlated matrix and angle matrix and apply inverse FFT to get the new gray image.

Step 6: Apply inverse conversion to get the cleared color image.

The reason behind the generation of this noise is electronics interferences, particularly in power signal at the time of image acquisition. Periodic noise has extraordinary features like spatially dependent and sinusoidal in nature at multiples of special frequency. In frequency domain, it's seems to be in the form of conjugate spots. It can be removed by using a narrow band notch or reject filter in a very convenient manner. However this method fails in case of quasi periodic noise.

III. ALGORITHM

This theory of detection is based on the thought that characters of interest (called *meaningful* features) are not liable to be created a random background procedure [5,6,7]. Choosing whether a component is significant or not is based on the *number of false alarms* (NFA) which relates to the average number of such a feature anticipated from the background process (therefore "false alarms") [7,8]. All the more absolutely, on account of real-valued features, if the features of interest are not prone to have a high value x, and given that the significant features are looked for among *N* features and then the NFA of the observed x is:

$NFA(x) = N\ Pr(X \geq x)$

where $Pr(X \geq x)$ is the probability that a random feature X taking after the background process is larger than or equal to x.

In the case a NFA has been defined, the element of interest are in majority of papers those such that NFA ≤ 1

A. Algorithm

Input: an image '*i*'(size X×Y) and its Fourier transform '*I*', patch size '*H*'

Step 1: first extract non-overlapping independent patches of size H×H over entire image and obtain *P* patches. Then evaluate F_R using step 4.

Step 2: Obtain the power spectra of patches for any (*n*, *m*) and obtain minimum value.

Step 3: for any (*n*, *m*), obtain NFA value.

Step 4: consider the spike map M_o^P on H×H spectrum such that $M_o^P(n,m)=1$ if NFA $\left(\left|c_{n,m}\right|\right)\leq 1$ and 0 otherwise

Step 5: Interpolate the outlier map M_o^P of size H×H to X×Y providing map of M_o of the probable false spikes in the original image spectrum. Multiplying the initial image spectrum by $1-M_o$ acts as notch filter, thus eliminating quasi periodic noise.

Step 6: Retrieve $\hat{n}$, estimation of the periodic noise components as the inverse Fourier transform (IFT) of $M_o I$ and $\hat{i}$ estimation of de-noised image as, $i - \hat{n}$.

IV. RESULTS

The experimental results are obtained on various images e. The frequency domain picture is shown in Figure 2-5. It is clear from the results that the obtained de-noised image of much more improved image equality.

A. Lena Image

Fig. 2 (a) Original Image

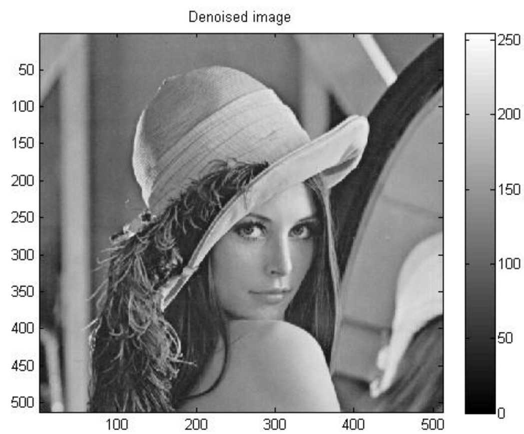

Fig. 2(b) De-noised Image

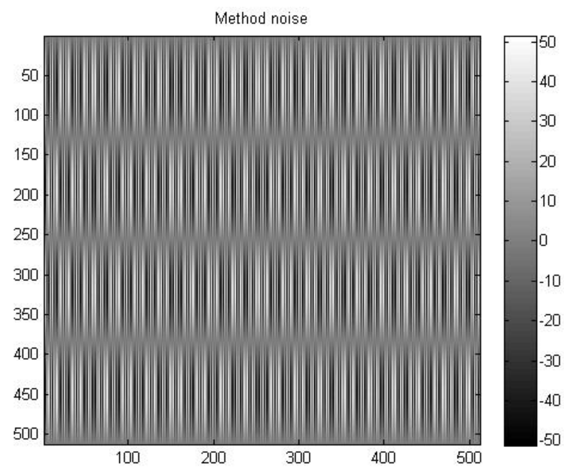

Fig. 2(c) Noise

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B. Baboon Image

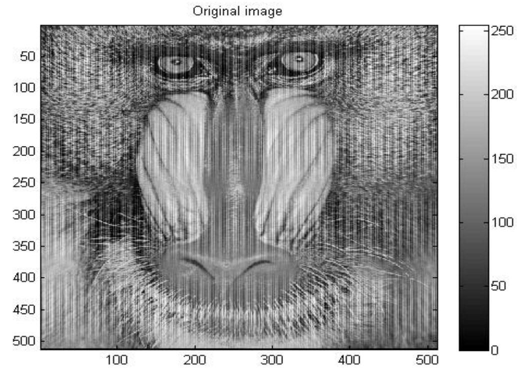

Fig. 3(a) Original Image

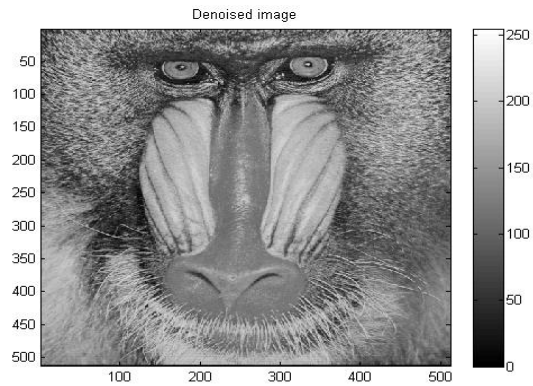

Fig. 3(b) De-noised Image

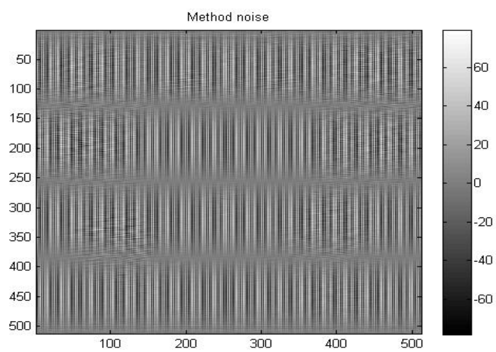

Fig. 3(c) Noise

C. Barbara Image

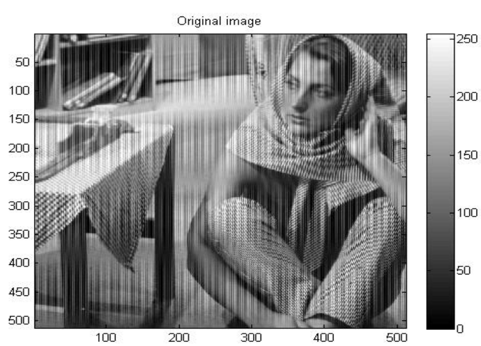

Fig. 4(a) Original Image

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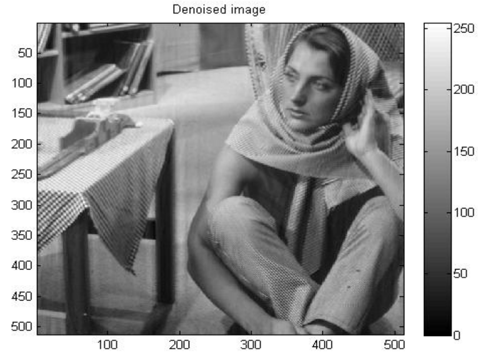

Fig. 4(b) De-noised Image

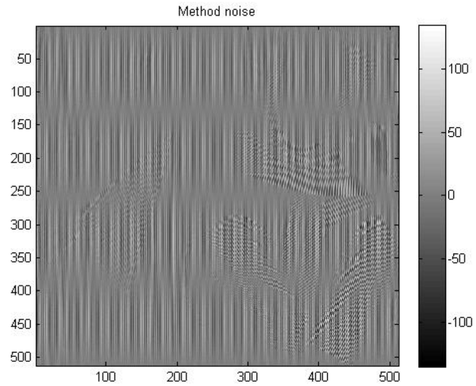

Fig. 4(c) Noise

D. Peppers Image

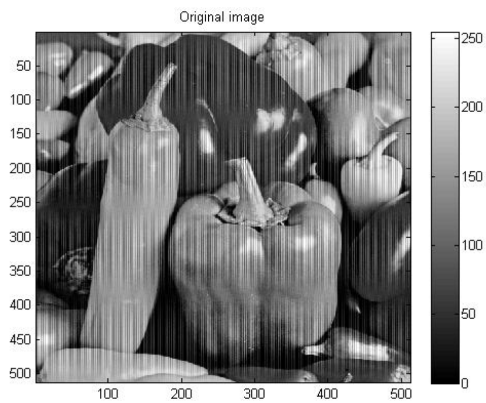

Fig. 5 (a) Original Image

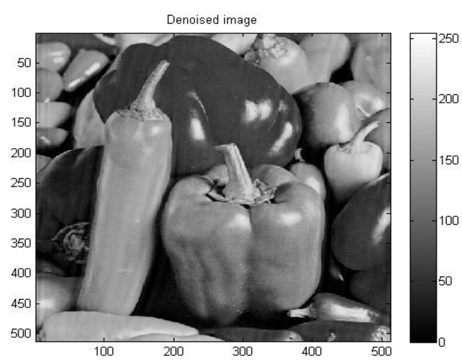

Fig. 5(b) De-noised Image

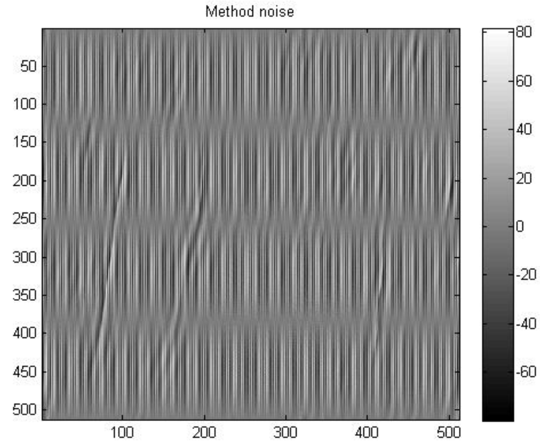

Fig. 5(c) Noise

V. CONCLUSIONS

Noise removal in an image is important and complicated problem due to the randomness of the noise. Most of the time noises are easily removed by measuring their pdfs. But in some cases estimation of noises is complicated which is superimposed on the signal spectral components. In such a case problem become complex as first, those frequency components has to be find out and careful removal of noise has to be done. In this work a quasi noise removal approach is presented. Simulation results are obtained Image database comprises of Lena, Baboon, Barbara and Peppers image.

On the basis of results obtained in the thesis, following conclusions can be made:

Due to the randomness of noise, filters needs to be carefully designed.

If pdfs of noises is known in advance, then filter design is not complex.

Quasi periodic noise is slowly varying noise, thus can be modelled as Wide sense stationary process.

Quasi periodic noise can be removed using notch filter.

The designed algorithm successfully removes the noise.

The concept of false alarm helps in detecting those spectral components which are corrupted with noise.

Noise spikes degrade the image severely.

Spectrum analysis helps us in finding out outliers.

Notch filter suppress the noise significantly.

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