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# Image Denoising Using Curvelet Transformation Using Log Gabour Filter

**Vishal Garg, Nisha Raheja**

***Abstract:*** ***In this we propose a new method to reduce noise in digital image. Image corrupted by Gaussian Noise is still a classical problem. In images to reduce the noise or to improve the quality of image peak signal to noise ratio (PSNR) is compared . Higher the PSNR better the quality of the image.In this paper we explain the method curvelet Transformation using log gabor filter Experimental results show that our method gives comparatively higher peak signal to noise ratio (PSNR), are much more efficient and have less visual artifacts compared to other methods.***

***Index Terms:*** ***Image Denoising, Discrete Wavelets Curvelet, Log Gabor filter.***

## I. INTRODUCTION

All digital images contain some degree of noise. Most of the times this noise is introduced by the camera when a picture is captured or during the transmission.Any Image denoising algorithm attempt to remove the noise from the image. Ideally, the resulting image will be the denoised image and will not contain any noise or added artifacts. Major denoising methods include Gaussian filtering, Wiener filtering,and wavelet thresholding. Many more methods have been developed; however, most methods make assumptions about the image that can lead to blurry effects. This paper will explain these assumptions and one of the measurements used will be the method noise, which is the difference between the image and denoised image [1].

## II. IMAGE FORMATION

Wavelet based image denoising is based on obtaining pixel values of images as proper data sets. Ordinary images seen on the computer screen have a matrix of two dimensions in term of xd and yd representing data in the horizontal axis and vertical axis. An image is a made up of pixels And a pixel called picture element is known as one of the many tiny dots that make up the representation of a picture in a screen of a computer. Each dot may have different values. With these explanations one can say that image with "256x512" resolution has "256" dots in xd and "512" dots in yd.

## III. NOISE IN IMAGE FORMATION

One common type of noise is Gaussian noise. This type of noise contains variations in intensity that is drawn from a Gaussian distribution and is a very good model for many kind of sensor noise. Noise is introduced by the camera when a picture is taken. Image denoising algorithms attempt to remove this noise from the image. Ideally, the resulting denoised image will not contain any noise or added artifacts. The image corrupted by different kinds of noises is a frequently encountered problem in image acquisition and transmission [2]. The noise comes from noisy sensors or channel transmission errors. Several kinds of noises are discussed here. The impulse noise (or salt and pepper noise) is caused by sharp, sudden disturbances in the image signal; its appearance is randomly scattered white or black (or both) pixels over the image i.e. all the pixels in the image become either white like salt or black like pepper. Gaussian noise is an idealized form of white noise, which is caused by random fluctuations in the signal. It has a normal distribution among all pixels in an image. Speckle noise (or more simply just speckle) can be modeled by random values multiplied by pixel values; hence it is also called multiplicative noise. If the image signal is subject to a periodic, rather than a random disturbance, we might obtain an image corrupted by periodic noise. Usually, periodic noise requires the use of frequency domain filtering. Whereas the other forms of noise can be modeled as local degradations, periodic noise is a global effect. However, impulse noise, Gaussian noise and speckle noise can all be cleaned by using spatial filtering techniques.

## IV. WAVELET TRANSFORM

A wavelet is like a small wave with finite energy, which has its energy concentrated in time or space area to give ability for the analysis of time-varying phenomenon. In other words a wavelet provides a time-frequency representation of the signal. Figure 1 shows the comparison of a wave with a wavelet. Left graph shows a Sine Wave with infinite energy and the right graph shows a Wavelet with finite energy.

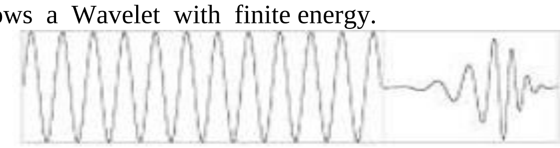

**Figure 1 Comparison of a wave and a wavelet**

Wavelet transformation (WT) was developed to overcome the shortcomings of the Short Time Fourier Transform (STFT), which can also be used to analyze non- stationary signals. As we know STFT gives a constant resolution at all frequencies, while WT uses multi-resolution technique for non-stationary signals by which different frequencies can be analyzed with different resolutions [3].

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Theory of Wavelet is based on analyzing the signals to their components by using a set of basis functions. One of the important characteristic of the wavelet basis functions is that they relate to each other by simple scaling and translation. The original wavelet function is used to generate all basis functions. Mainly This is designed with the desired characteristics of the associated function. For multi solution transformation, there is a need for another function that is known as scaling function which makes analysis of the function to a finite number of components.

## V. IMAGE FUSION BASED UPON CURVELET TRANSFORM

The curvelet transformation has evolved as a tool for the representation of curved shapes in graphical applications. After that it was extended to the fields of edge detection ,image denoising and also to image fusion( Ali ,Dakany ,sood and Abd ,2008). When the curvelet transform (CT) is introduced to image fusion, the fused image will take more characteristics of original images and more information for fusion is maintained( Sun,li and Yang ,2008) The objective of curvelet transform (CT) is to generate an image that will be of better quality in terms of reduced noise than the original image. Conventional methods have very erratic decision making capabilities when compared with curvelet method.. Curvelet Transform(CT) is a new multi-scale representation most suitable for images(objects) with curves.

Curvelet Transformation is an enhancement technique that is used to reduce image noise and also to increase the contrast of structures of interest in image. In Comparison with other techniques, this method can manage the vagueness and ambiguity in many image reconstruction applications efficiently. ( Starck , Candes and Donoho ,2002).

## VI. LOG GABOR FILTER

In Gabor filters are mainly recognized as one of the best choices for obtaining localized frequency information. These filters offer the best simultaneous localization of spatial and frequency information. Two most important characteristics to note are: First, Log-Gabor functions, by definition, always have no DC component, which contributes towards the improvement in the contrast edges and ridges of images. Second, the transfer function of the Log-Gabor function has an extended tail at the high frequency end, which enables us to obtain wide spectral information with localized spatial extent and consequently helps us to preserve the true ridgelet structure of images (Lajevardi and Hussain ,2009) .

The “Gabor filter bank” is a well known technique to determine a feature domain for the representation of an image. Such a Gabor filter bank can be designed by varying the spatial frequency and orientation of a Gabor filter that mimics a band-pass filter. However, a Gabor filter can be designed for a maximum bandwidth of 1 octave with a small DC component in the filter. To overcome this limitation, Field proposes the Log-Gabor filter. A Log-Gabor filter has no DC component so it can be constructed with any arbitrary bandwidth. There are two important characteristics of the Log-Gabor filter. First the Log-Gabor filter function always has zero DC components which further contribute to improve the contrast edges and ridges of images. Second, the Log-Gabor function also has an extended tail at the high frequency end which allows it to encode images more efficiently than the ordinary Gabor function( Mara and Fookesb ,2010). For obtaining the phase information log Gabor wavelet is used for feature extraction. It has also been observed that the log filters (that use Gaussian transfer functions viewed on a logarithmic scale) can code natural images better than Gabor filters. Statistics of natural images indicate the presence of high-frequency components. Since ordinary Gabor filters under-represent high frequency components, the log filters are a better choice to be used with images (Mehrotra , Majhi and Gupta).Log-Gabor filters, consist of a complex filtering arrangement in p orientations and k scales, whose expression in the log-polar Fourier domain is as follows:

$$G(\rho,\theta,p,k) = \exp\left(-\frac{1}{2}\left(\frac{\rho-\rho_k}{\sigma_\rho}\right)^2\right)\exp\left(-\frac{1}{2}\left(\frac{\theta-\theta_{k,p}}{\sigma_\theta}\right)^2\right) \quad \text{----1}$$

in which ( Ꝓ , Ɵ) are coordinates of the log-polar and σp and σƟ are the angular and radial bandwidths (common for all filters). The pair ( Ꝓk and Ɵk,p ) corresponds to the frequency center of the filters, where the variables p represents the orientation and k represents scale selection. In addition, the scheme is completed by a Gaussian low-pass filter G ( Ꝓ ,Ɵ, 1 ,K) (approximation).

## VII.METHODOLOGY

The methodology used for image denoising is the introduction of log gabor filter inside the Curvelet Transformation so that high pass and low pass filters can be replaced with this technique. Our technique not only gives the good PSNR value but also provide the best visual quality . The results of various algorithms will be interpreted on the basis of different quality metrics.

Image denoising is basic work for image processing, analysis and computer vision. This proposes a Curvelet Transformation based image denoising, that is combined with Gabor filter in place of the low pass filtering in the frequency transform domain. We demonstrated this through simulations with images contaminated by white Gaussian noise that our new developed scheme exhibits a much better performance in both PSNR (Peak Signal-to-Noise Ratio) and visual effect.

Thus, the methodology that is used for implementing these objectives can be summarized as follows:-

1. Study all the methods of the Image Denoising.
2. Then Attenuate the color frequencies by using Log Gabor Filter.
3. Apply the Curvelet Transform.
4. Compare the image quality using PSNR Tool.

Work Flow for Image denoising using Log Gabor filter using Curvelet transformation


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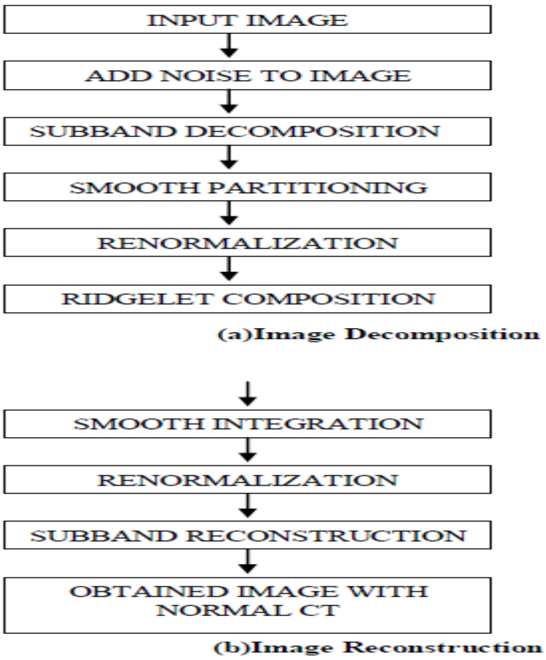


**Fig 2 Curvelet transform processing flowchart**

**(A)Image Decomposition**

(I.).Subband decomposition

In this phase the image is filtered into several subbands.

$$f \rightarrow (P_0 f, \Delta_1 f, \Delta_2 f, \cdots),$$

---- (1)

(a) Divide the image into resolution layers.

(b) Each layer will contains details of different frequencies:

P0 – Low-pass filter.

Δ1, Δ2, … – Band-pass (high-pass) filters.

(c) The original image can then be reconstructed from these sub-bands:

$$f = P_0(P_0 f) + \sum_s \Delta_s(\Delta_s f)$$

---- (2)

(d) Low-pass filter Φ0 deals with low frequencies near |ξ|≤1.

(e) Band-pass filters Ψ2s deals with frequencies near domain |ξ|∊[22s, 22s+2].

(f) Go on Recursive construction –

Ψ2s(x) =24s Ψ(22sx). ---- (3)

(g)The decomposition of sub-bands can be approximated using the well known wavelet transform. Using wavelet transform, f is decomposed into S0, D1, D2, D3, D4 etc. P0 f is partially constructed from S0 and D1, and may include also D2 and D3. Δs f is constructed from D2s and D2s+1.

(h) P0 f is "smooth" (low-pass), and can be efficiently represented with wavelet base.

(II). Smooth Partitioning

In this phase we will dissect the layer into small partitions. A grid of dyadic squares can be defined as

$$Q_{(s,k_1,k_2)} = \left[\frac{k_1}{2^s}, \frac{k_1+1}{2^s}\right] \times \left[\frac{k_2}{2^s}, \frac{k_2+1}{2^s}\right] \in \mathbf{Q}_s$$

---- (4)

Qs – all the dyadic squares of the grid .

(a)Let w be a smooth windowing function with 'main' support of size 2-s×2-s..For each of these squares, wQ is a displacement of w localized near Q. Multiplying Δs f with wQ (∀Q∊Qs) produces a smooth dissection of the function into 'squares'

$$h_Q = w_Q \cdot \Delta_s f$$

---- (5)

The windowing function *w* is a non-ve smooth function.

(b) Partitioning of the energy:

The energy of certain pixel ($x_1$,$x_2$) is divided between all sampling windows of the grid

$$\sum_{k_1,k_2} w^2(x_1 - k_1, x_2 - k_2) \equiv 1$$

---- (6)

***(III.).Renormalization***

Renormalization is centering each dyadic square to the unit square [0,1]×[0,1]. For each Q, the operator TQ is defined as:

$$(T_Q f)(x_1, x_2) = 2^s f(2^s x_1 - k_1, 2^s x_2 - k_2)$$

---- (7)

Each square is renormalized by

$$g_Q = T_Q^{-1} h_Q$$

---- (8)

(IV).Ridget Analysis

(a) Each normalized square is analyzed in the ridgelet system:

$$\alpha_{(Q,\lambda)} = \langle g_Q, \rho_\lambda \rangle$$

---- (9)

(b) The ridge fragment has an aspect ratio of 2-2s×2-s. After the renormalization, it has localized frequency in band |ξ|∊[2s, 2s+1].

(c) A ridge fragment needs only a few ridgelet coefficients for representing it.

(B) Image Reconstruction

The Inverse of the Curvelet Transform:

(I) Ridgelet Synthesis

$$g_Q = \sum_\lambda \alpha_{(Q,\lambda)} \cdot \rho_\lambda$$

---- (10)

(II) Renormalization

$$h_Q = T_Q g_Q$$

---- (11)


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(III) Smooth Integration…

$$\Delta_s f = \sum_{Q \in \mathbf{Q}_s} w_Q \cdot h_Q$$

---- (12)

(IV) Sub-band Recomposition

$$f = P_0(P_0 f) + \sum_s \Delta_s(\Delta_s f)$$

---- (13)

**Proposed Method**

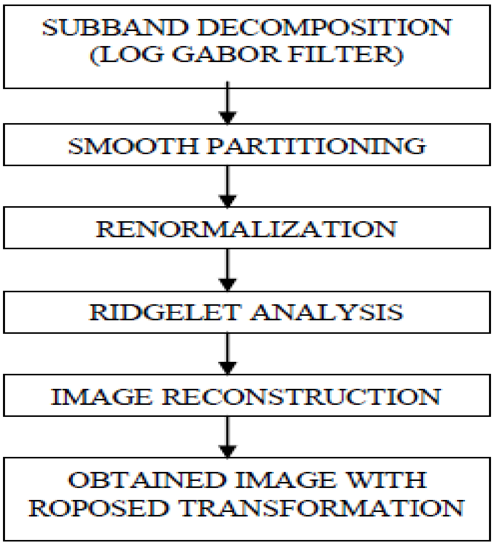


**Fig 3 Flowchart of Proposed Algorithm**

**PROPOSED ALGORITHM STEPS**

Step I: Take noisy image.

Step II: Applying curvelet Transform as under.
(a) Sub band decomposition
(b) Smooth Partioning
(c) Renormalization
(d) Redget analysis
Step III: In Sub band decomposition
(a) Divide imgae into resolution layers
(b) Each layer contains details of different frequencies.
(c) These frequiencies are attenuates and approximate with the help of log gabor filter.

This Step has following characterstics –

(a).The main particularity of this novel scheme is the construction of the low-pass and high-pass filters.

(b).Log-Gabor filters basically consist in a logarithmic transformation of the Gabor domain which eliminates the annoying DC-component allocated in medium and high-pass filters.

(c).Such a complete scheme approximates flat frequency response and therefore exact image reconstruction which is obviously beneficial for applications in which inverse transform is demanded, such as texture synthesis, image restoration, image fusion or image compression.

Step IV: Now go for a Smooth portioning ,in this we will dissect the layer into small portions as shown in eq. 4,5 and 6.

Step V: In Renormalization each square is renormalized by using the specified formula.

Step VI: Ridget Analysis is taking place, which is explained by eq 9

Step VII : Reconstruction is taking place,for this take inverse of curvelet transform .

Step VIII: Output the final Denoised image.

## VIII. CONCLUSION

In this paper, a fremwork for denoising based on the prior knowledge of the noise staticstics has been presented. It is found that Curvelet act as the Good Denoising Method in both the aspects PSNR and better visual quality.

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