A Review On Image Denoising Using Wavelet Transform And Median Filter Over AWGN Channel

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Abstract: In the past two decades, many noise reduction techniques have been developed for removing noise and retaining edge details in images. The process of removing noise from the original image is still a demanding problem for researchers. There have been several algorithms and each has its assumptions, merits, and demerits. The prime focus of this paper is related to the pre processing of an image before it can be used in applications. The pre processing is done by de-noising of images. In order to achieve these de-noising algorithms, filtering approach and wavelet based approach are used and performs their comparative study. Image filtering algorithms are applied on images to remove the different types of noise that are either present in the image during capturing or injected into the image during transmission. Wavelet transform and median filter are used for the image reconstruction and denoising. In this paper, we propose fast and high-quality nonlinear algorithms for denoising digital images corrupted by mixed Poisson-Gaussian noise.

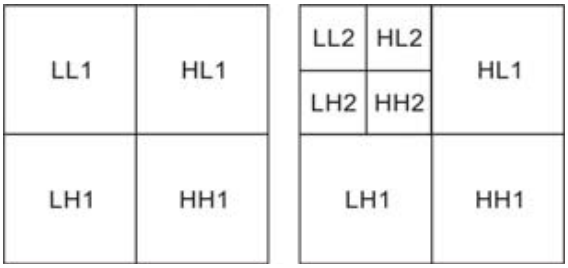
Keywords: Image, Noise, Wavelet transform, Median Filter, Phase Shift Key

Introduction

An image is a two dimensional function f(x, y), where x and y are plane coordinates, and the amplitude of f at any pair of coordinates (x, y) is called the gray level or intensity of the image at that point. Digital images consist of a finite number of elements where each element has a particular location and value. These elements are called picture elements, image elements and pixels. There are two types of images i.e. grayscale image and RGB image. Gray scale image has one channel and RGB image has three channels i.e. red, green and blue. Image noise is unwanted fluctuations. There are various types of image noises present in the image like gaussian noise[4]. There are various noise reduction techniques which are used for removing the noise. Most of the standard algorithms use to de-noise the noisy image and perform the individual filtering process. The result is that it generally reduces the noise level. But the image is either blurred or over smoothed due to losses like edges or lines. Noise reduction is used to remove the noise without losing much detail contained in an image. To achieve this goal, we use the mathematical function known as the wavelet transform to localize an image into different frequency components or useful sub-bands and effectively reduce the noise in the sub-bands into different frequency components or useful sub-bands and effectively reduces the noise in the sub-bands[4]. Image denoising is a process of removing the noise from an image without distorting the quality. In general, an image is often corrupted by noise during its transmission through a channel. Wavelet transform and Filtering are widely used for image de-noising[4].. Phase-shift keying is a digital modulation scheme that conveys data by changing, or modulating, the phase of a reference signal. For that simply load a image then we have to convert image into binary data. This binary data convert into serial form then it can be modulate and then demodulate using PSK technique. Again we have to convert serial into parallel form. Inverse Wavelet Transform as well as median filter is used for image reconstruction.

Discrete Wavelet Transform

A ‘wavelet’ is a small wave which has its energy concentrated in time. It has an oscillating wavelike characteristic & it as time-scale and time-frequency analysis tools have been widely used in topographic reconstruction and still growing. Working in the wavelet domain is advantageous because the DWT tends to concentrate the energy of the desired signal in a small number of co-efficients, hence, the DWT of the noisy image consists of a small number of coefficients with high Signal Noise Ratio (SNR) and a large number of coefficients with low SNR. After discarding the coefficients with low SNR (i.e., noisy coefficients) the image is reconstructed using inverse DWT. As a result, noise is removed or filtered from the observations[3]. The DWT is identical to a hierarchical sub band system where the sub bands are logarithmically spaced in frequency and represent octave-band decomposition. By applying DWT, the image is actually divided i.e., decomposed into four sub bands and critically sub sampled as shown in Figure.1(a). These four sub bands arise from separable applications of vertical and horizontal filters. The sub bands labeled LH1, HL1 and HH1 represent the finest scale wavelet coefficients, i.e., detail images while the sub band LL1 corresponds to coarse level coefficients, i.e., approximation image. To obtain the next coarse level of wavelet coefficients, the sub band LL1 alone is further decomposed and critically sampled. This results in two- level wavelet decomposition as shown in Figure.1(b)[3].



(a) One-Level (b) Two-Level

Figure 1: Image decomposition

Image Reconstruction with wavelet transform used 2D version of the analysis and synthesis filter banks. In the 2D (image) case, the 1D analysis filter bank is first applied to the columns of the image and then applied to the rows. If the image has N1 rows and N2 columns, then after applying the 1D analysis filter bank to each column, two subband images are created, each having N1/2 rows and N2 columns; after applying the 1D analysis filter bank to each row of both of the two subband images, four subband images are generated, each having N1/2 rows and N2/2 columns.

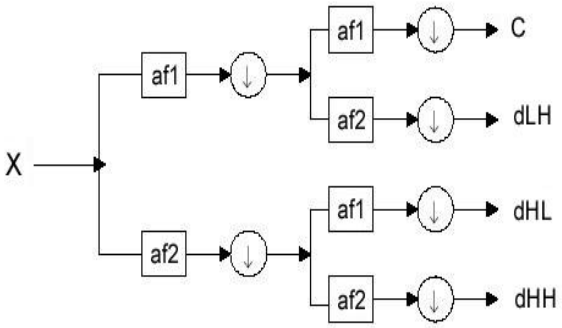


Figure 2: One stage in the multi-resolution wavelet decomposition of an image

Two Dimensional Discrete Wavelet Transform (2-D DWT)

The DWT is extensively used in its non-redundant form known as standard DWT. The filter bank implementation of standard DWT for images is viewed as 2-D DWT. There are certain applications for which the optimal representation can be achieved through more redundant extensions of standard DWT such as WP and SWT. Image-processing applications require two-dimensional implementation of wavelet transform. Implementation of 2-D DWT is also referred to as 'multidimensional' wavelet transform in literature. The implementation of an analysis filter bank for a single level 2-D DWT is shown in figure.2[3].

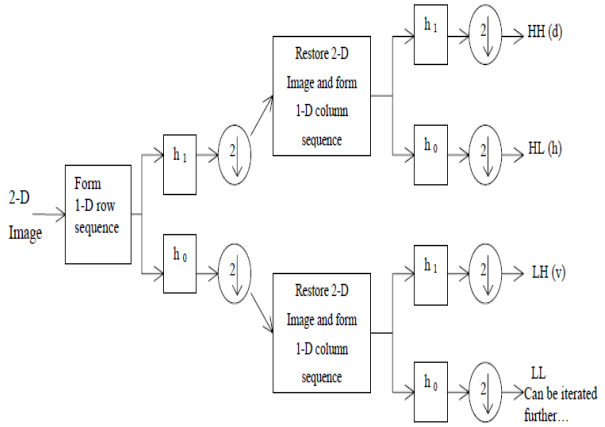


Figure 3: Single level analysis filter bank for the 2-D DWT

Thresholding

Wavelet thresholding is a signal estimation technique that exploits the capabilities of wavelet transform for signal denoising. It removes noise by killing coefficients that are insignificant relative to some threshold, and turns out to be simple and effective, depends heavily on the choice of a thresholding parameter and the choice of this threshold determines, to a great extent the efficacy of denoising. Threshold Selection: As one may observe, threshold selection is an important question when denoising. A small threshold may yield a result close to the input, but the result may still be noisy. A large threshold on the other hand, produces a signal with a large number of zero coefficients. This leads to a smooth signal. Paying too much attention to smoothness, however, destroys details and in image processing may cause blur and artifacts. Thresholding Method: Some of thresholding methods are: (i) Hard thresholding, (ii) Soft thresholding, (iii) Semi-soft Thresholding and (iv) Quantile thresholding. In our implementation, soft thresholding method is used to analyze the performance of denoising system for different levels of DWT decomposition, since soft thresholding results in better denoising performance than other denoising methods. Soft thresholding leads to less severe distortion of the object of the interest than other thresholding methods. Several approaches have been suggested for setting the threshold for each band of the wavelet decomposition.

Haar Wavelet Transform

The Haar Wavelet is a certain sequence of rescaled "square-shaped" functions which together form a wavelet family[6].

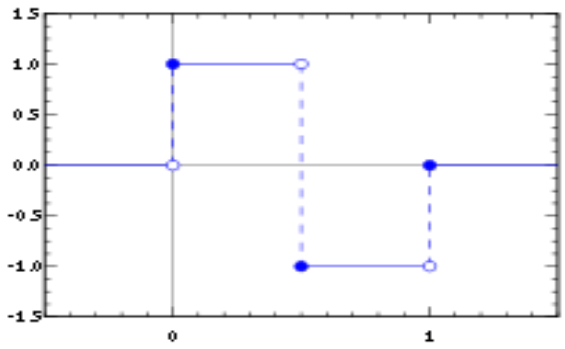


Figure 4: Haar wavelet Transform

The Haar wavelet's mother wavelet function ψ(*t*) & its scaling function ϕ(*t*) can be described as

$$\psi(t) = \begin{cases} 1 & 0 \le t < 1/2, \\ -1 & 1/2 \le t < 1, \\ 0 & \text{otherwise.} \end{cases}$$

$$\phi(t) = \begin{cases} 1 & 0 \le t < 1, \\ 0 & \text{otherwise.} \end{cases}$$

Noise in Image

Image noise is random variation of brightness or color information in images, and is usually an aspect of electronic noise. It can be produced by the sensor and circuitry of a scanner or digital camera. The sources of noise in digital images arise during image acquisition and/or transmission with unavoidable shot noise of an ideal photon detector[2]. Noisy image can be modeled as

$$Y_{i,j} = X_{i,j} + n_{i,j}$$ Where i, j = 1: N [2]

Additive white Gaussian noise (AWGN)

The standard model of amplifier noise is additive, Gaussian, independent at each pixel and independent of the signal intensity, caused primarily by Johnson–Nyquist noise (thermal noise). In color cameras where more amplification is used in the blue color channel than in the green or red channel, there can be more noise in the blue channel[2]. Gaussian noi**s**e is a noise that has its PDF equal to that of the normal distribution, which is also known as the Gaussian distribution. Gaussian noise is most commonly known as additive white Gaussian noise. Gaussian noise is properly defined as the noise with a Gaussian amplitude distribution[4]. Among various image-denoising strategies, the transform-domain approaches in general, and in particular the multiscale ones, are very efficient for AWGN reduction[1].

Image filtering

Image filtering is useful for the many applications, including smoothing, sharpening, removing noise, and edge detection. The process used to apply filters to an image is known as convolution, and may be applied in either the spatial or frequency domain.

Median Filter

The Median Filter is performed by taking the magnitude of all of the vectors within a mask and sorted according to the magnitudes. The pixel with the median magnitude is then used to replace the pixel studied. Simple Median Filter has an advantage over the Mean filter since median of the data is taken instead of the mean of an image. The pixel with the median magnitude is then used to replace the pixel studied. The median of a set is more robust with respect to the presence of noise[2].

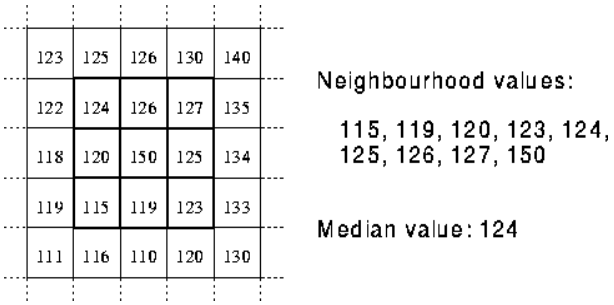


Figure 5: Median Filter

The median filter is a nonlinear digital filtering technique, often used to remove noise. Such noise reduction is a typical pre-processing step to improve the results of later processing. The median is calculated by first sorting all the pixel values from the surrounding neighbourhood into numerical order and then replacing the pixel being considered with the middle pixel value. The median is a statistical concept whereby in a given sorted list of numbers, the median is the center value of the list[7]. The median filter is given by

MEDIANFILTER(x1, ...,xN) = [7]

MEDIAN(kx1k2,...,kxNk2)

Phase Shift Keying

Phase-shift keying (PSK) is a digital modulation scheme that conveys data by changing, or modulating, the phase of a reference signal. PSK modulation in Matlab can be simulated using the pskmod() function and demodulation can be performed using pskdemod(). The pskmod() produces a sequence of channel symbols (e.g. fs3, s3, s5, s6, s1, : : :g).

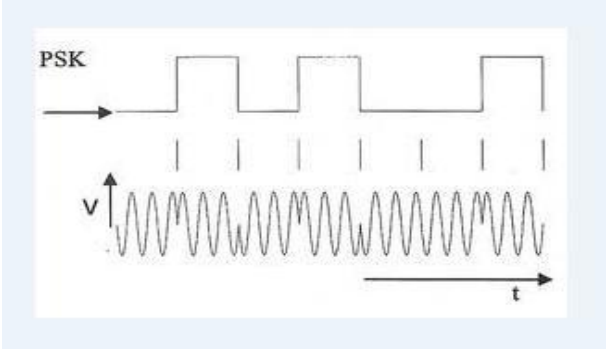


Figure 6: PSK Waveform

Conclusion

In this paper, we will obtain denoised image using Image denoising technique Wavelet transform and median filter during the transmission of image over the AWGN channel using the Phase Shift Key system.

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