Video Denoising based on Stationary Wavelet Transform and Center Weighted Median Filter

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Abstract

Noise removal using wavelet has the characteristic of preserving signal uniqueness even if noise is going to be minimized. Images are getting corrupted by impulse noise during image acquisition and transmission. A new median filter termed as the center weighted median filter (CWMF) in the wavelet coefficient domain combined with stationary wavelet transform (SWT) is proposed for video denoising. This filter iteratively smoothes the noisy wavelet coefficients variances preserving the edge information contained in the large magnitude wavelet coefficients. This Paper deals with uncompressed video of .avi format. The proposed algorithm works well for suppressing Gaussian noise with noise density from 10 to 70% while preserving image details. Simulation results show that higher peak signal to noise ratio can be obtained as compared to other recent image denoising methods.

Keywords: Denoising, SWT, CWMF, PSNR and MSE.

1 INTRODUCTION

Many scientific datasets are tainted with noise either because of the data acquisition process or because of naturally occurring phenomena. Pre-processing is the first step in analysing such datasets [3]. There are several different approaches to denoise images. The main difficulty faced during diagnosis is the noise introduced due to the consequence of the coherent nature of the image capture. In Image Processing applications, linear filter tends to smudge the edges and do not remove Gaussian and mixed Gaussian impulse noise effectively [4]. Gaussian noise is an additive noise which degrades image quality that originates from several microscopic diffused reflections leads to categorize fine detail of the images in diagnostic examinations. Noise represents unwanted information which destroys image quality. The noise usually corrupts images by replacing some of the pixels of the original image with new pixels having luminance values near or equal to the minimum or maximum of the allowable dynamic luminance range.

In Gaussian noise, each and every pixel of the image gets affected by noise. Image denoising is the method of removing redundant noise from the corrupted images. Several filters are used for denoising the images. The main goal of the filtering process is to remove noise while preserving edges and image detail information. In general image denoising provides the quality images by increasing the PSNR values.

Denoising is an important task in image processing and analysis and it plays a significant role in modern applications in different fields including medical imaging and pre-processing for computer vision. Image denoising technique removes out noise which is added in the original image. Noise is nothing but the existent world signal. In images, noise restraint is a particularly flimsy task. In this task, noise reduction and the preservation of actual image features are the main focusing parts.

Noise filtering can be used as replacing every noisy pixel in the image with a new value depending on the adjacent region. Filters that are used for the purpose of denoising are broadly

divided into two types, linear and nonlinear filter. Linear filter tends to blur the edges and other image details. Also these filters perform poorly on images corrupted by non- Gaussian type of noises. Hence for the removal of impulsive noise, nonlinear filters are used. Image denoising finds application in fields such as astronomy, in medical imaging and in forensic science. Conventional median filtering approaches apply the median operation to each pixel totally, without considering whether it is uncorrupted or corrupted. As a result, uncorrupted pixels are filtered and this causes image quality deprivation [6].

An intuitive solution to overcome this problem is to implement noise detection mechanism prior to filtering; hence, only those pixels identified as "corrupted" would undergo the filtering process, while those identified as "uncorrupted" would remain intact. A fusion technique is proposed to find the best possible solution, so that after denoising PSNR and MSE values of the image are optimal. The proposed method is based on SWT and center weighted median filtering, which utilize the potential features of the combination of both wavelet and center weighted median.

This paper only deals with uncompressed video of .avi format. This paper is organized as follows. Section 2 discusses the stationary wavelet transform for denoising Gaussian noise. Section 3 describes the center weighted median filter for denoising noise. The proposed scheme is explained in Section 4. Experimental outcomes are given in Section 5. Finally, Conclusions are discussed in Section 6.

2 STATIONARY WAVELET TRANSFORM

A utensil for the analysis of transient, non-stationary or time varying phenomenon that has energy concentrated in time is a wavelet. The SWT can be obtained by modifying the basic DWT algorithm [1], [2]-[3]. The DWT does not preserve translation invariance due to sub-sampling operations in the pyramidal algorithm. The SWT has been introducing because it defends the property that a translation of the original signal does not necessarily involve a translation of the corresponding wavelet coefficients. To halve the bandwidth from one level to another level, the SWT make use of recursively dilated filters instead of sub-sampling.

The stationary wavelet transform (SWT) was introduced in 1996 to formulate the wavelet decomposition time invariant [5]. This improves the power of wavelet in signal de-noising. This paper exploits the benefits of stationary wavelet transform in suppressing noise at high frequencies and median filter to suppress noise in low frequency bands.

The proposed algorithm is divided into two steps. After taking SWT to the noisy image, soft thresholding method is applied to the details sub-bands; then a transformed image is generated from approximation sub-band only while the other sub-bands are made equal to zero, applying inverse SWT to the generated 2-D array, then applying the weighted median filter, to remove the residual noise in the low frequency band. After that the approximation band is returned by applying SWT to the denoised signal, the resulted approximation sub-band is grouped with the thresholded sub-bands, applying inverse SWT to obtain the denoised image.
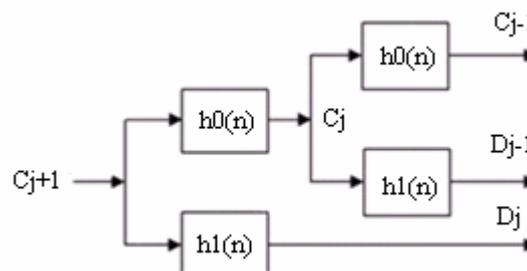

Fig. 1. Wavelet Decomposition

The SWT is an inherent redundant scheme, as each set of coefficients contains the same number of samples as the input. So for a decomposition of N levels, there is a redundancy of 2N. At each level, when the high-pass and low-pass filters are applied to the data, the two new sequences have the same length as the original sequences. To do this, the original data is not decimated. However, the filters at each level are modified by padding them out with zeros. However, for stationary or redundant transform, instead of downsampling, an upsampling procedure is carried out before performing filter convolution at each scale.

The Discrete Wavelet Transform (DWT) is the simplest way to implement MRA. It necessitates decimation by a factor 2N, where N stands for the level of decomposition, of the transformed signal at each stage of the decomposition. As a result, DWT is not translation invariant which leads to block artifacts and aliasing during the fusion process between the wavelet coefficients. For this reason, we use the Stationary Wavelet Transform (SWT). For the SWT scheme the output signals at each stage are redundant because there is no signal down- sampling; insertion of zeros between taps of the filters are used instead of decimation.

3 CENTER WEIGHTED MEDIAN FILTER

The standard median filter is a simple rank selection filter that attempts to remove impulse noise by changing the luminance value of the center pixel of the filtering window with the median of the luminance values of the pixels contained within the window [7]. Although the median filter is simple and provides a reasonable noise removal performance, it removes thin lines and blurs image details even at low noise densities. Median filter replace every pixel of the image by the median value of its neighborhood. The filter performs well for noise densities less than 50% above which the noise present in the neighborhood is more than the information and hence the filter's performance deteriorates [8]. Fig. 2 describes the function of Median Filter.

Sorted Pixel values: 3, 3, 4, 4, 4, 5, 5, 87
Median Filtered value: 4

Fig. 2.   Median Filter

3.1 Median Filter

It provides better removal of impulse noise from corrupted images. It replaces the center value with the median of all the pixels in the window. According to window size each pixels in the window is taken and sort the pixel then find the median of the each window. Then this median value is replaced by center value.

3.2 Weighted Median Filter

The basic idea is to give weight to the each pixel. Every pixel is given a weight. This weight is multiply with pixel. According to this weight the pixels are sort into ascending order, and then find the median value from the sorted list. This value is replaced with center value.

3.3 Center Weighted Median Filter

In CWM center pixel of window is considered as test pixel. Check that the center pixel is less than minimum value available in window and center pixel is greater than maximum value available in window then center pixel is considered as corrupted pixel [10]. This corrupted pixel is replaced by calculated value. Weight is given to the center pixel then sorts all element of window in ascending order and calculate median of elements. The weighted median filter and the center weighted median filter are modified median filters that give more weight to the appropriate pixels of the filtering window.

These filters have been proposed to avoid the inherent drawbacks of the standard median filter by controlling the tradeoff between the noise suppression and detail preservation. When one give more weight to the central value of the window a special case of weighted median filters called the Center Weighted Median filter will be produced, and thus it is easier to design and implement the general weighted median filters [9]. Obviously, a center weighted median filter with a larger central weight performs better in detail preservation than with a smaller central weight. The central weight should be carefully selected depending on the characteristics of the input image and its noise. The advantage of center weighted median filter is to reduce noise and to preserve fine details.

4 PROPOSED SYSTEM

In the hybrid work, two techniques namely, wavelet thresholding and center weighted median filters are combined to form a hybrid denoising model. The proposed method performs median filtering on the wavelet coefficients to denoise an image degraded by Gaussian Noise. These techniques are used to suppress the Gaussian noise. This Paper only deals with uncompressed video of .avi format. Fig.3 describes the process of noise removal.

Wavelets have made quite a splash in the field of image processing. Proposed model is the newly designed hybridized one as shown in fig.4. In this model, the image is denoised first with wavelet decomposition into four sub-bands using haar wavelet filters. It is used for suppressing the Gaussian noise. Resultant coefficients are used for image reconstruction with IWT. The results obtained after inverse transform are then used to reconstruct the image.
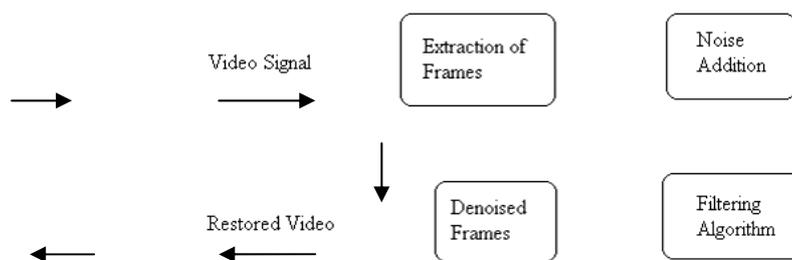

Fig. 3. Noise removal process

In the last level, center weighted median filter is used to remove noise present in the image during transformation. The final denoised image is obtained. Wavelets work for decomposing signals into hierarchy of increasing resolutions. The advantage of wavelet denoising is possible to remove the noise with little loss of details. The wavelet mode denoises only the Gaussian type of noise. So when multiple noise present in the image it will remove only Gaussian the remaining noise are unremoved. So for removing the remaining noise and to preserve the fine details CWM filter is applied. The advantage of center weighted median filter is that it can denoise the large window size.
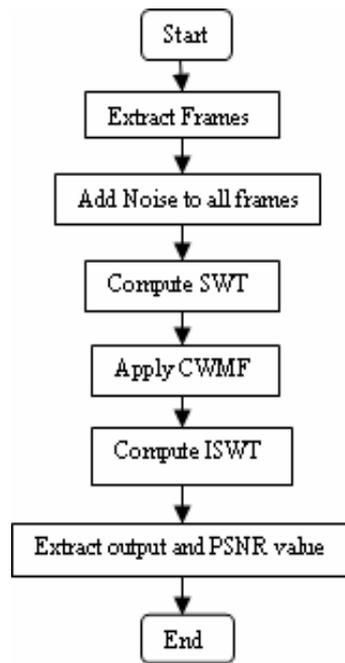
Fig. 4. Flow chart of proposed system

The proposed algorithm is described in this section; it is applied for each (Red, Green, and Blue) band separately. It consists of the following steps:

1- Read the noisy color image
2- Apply SWT (one level of decomposition)
3- Reconstruct a new image from LL1 subband only while making other subbands equal to zero, by applying inverse stationary wavelet transform.
4- Apply center weighted median filter to the reconstructed image in spatial domain.
5- Reapplying SWT to the resultant image of step 4.
6- Apply inverse stationary wavelet transform, to get the denoised image.

5 RESULTS AND DISCUSSIONS

The video used for testing this algorithm is acquired from "http://www.frequency.-com/video". The performance of the proposed algorithm is tested for various levels of noise corruption and compared with the Existing algorithms. The algorithm is implemented in MATLAB 7.2 on a PC equipped with 2.4 GHz CPU and 2 GB RAM memory for the evaluation of computation time of algorithms. The Quantitative performance of the proposed algorithm is evaluated frame by frame based on Peak signal to noise ratio and Mean Square Error which is given in (1) and (2) respectively.

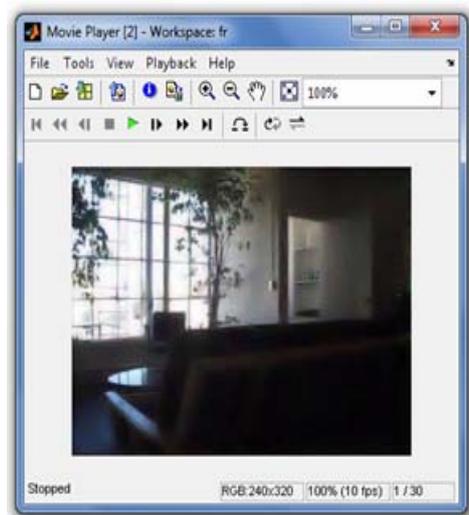$$PSNR = \log_{10} 10 \frac{255^2}{MSE} \qquad (1)$$

$$MSE = \frac{1}{MN} \sum_{i=1}^{M} \sum_{j=1}^{N} (R_{i,j} - X_{i,j})^2 \qquad (2)$$
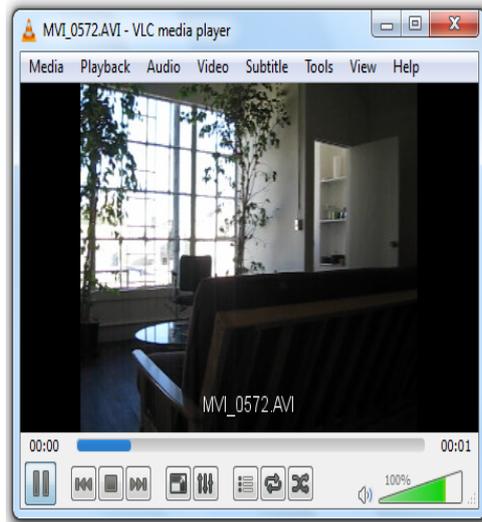
(a)
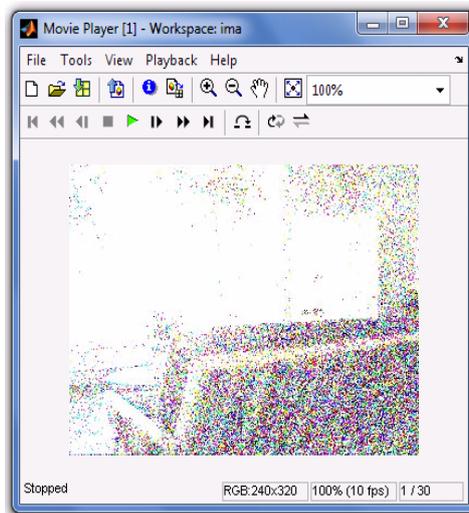
(b)

(c)

Fig. 5. (a) Input Video (b) Video corrupted by random noise with 30 Percent noise density and (c) Restored Video

In addition to the visual quality, the performance of the developed algorithm and other standard algorithms are quantitatively measured by the following parameters such as peak signal to noise ratio (PSNR) and Mean square error (MSE). The proposed algorithm shows excellent noise suppression and edge preservation capabilities. The proposed algorithm effectively removes the random noise and preserves edges for low, medium and high detail images. Fig. 5 describes the graph plot between PSNR value and noise density for different algorithms [13].

TABLE I
PSNR FOR DIFFERENT NOISE DENSITIES

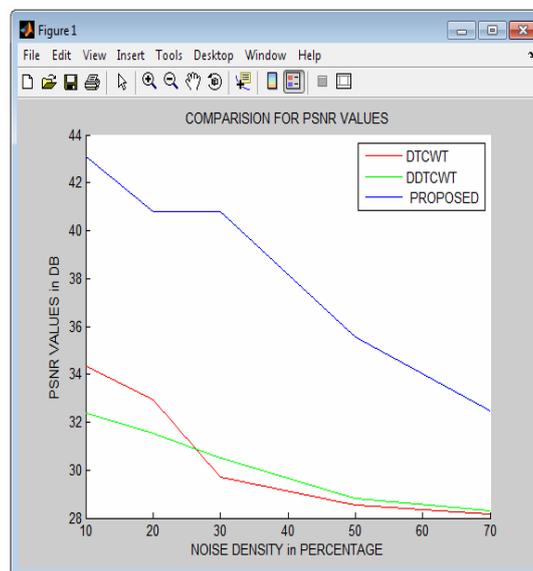| Noise Density (%)	Existing System		Proposed System PSNR (db)
	DTCWT PSNR (db)	DDDTCWT PSNR (db)	
10	34.3432	32.3623	43.0659
20	32.9458	31.5489	40.7863
30	29.6963	30.4888	38.9385
50	28.5542	28.8194	35.5476
70	28.1860	28.2885	32.4698

Fig. 6. Graph between Existing and Proposed system

The PSNR value of the proposed algorithm is compared against the existing methods by varying the noise density from 10% to 70% and is shown in Table I. From the table, it is clear that the proposed system gives better PSNR values irrespective of the nature of the input image. This algorithm takes 1628 s for computing. Time complexity is higher when compared to other algorithms. But PSNR value obtained is higher.

6 CONCLUSIONS

A new technique based on the hybridization of stationary wavelet transform and center weighted median filters for denoising a noisy video. Results prove that utilization of center weighted median filters in combination with stationary wavelet transform deteriorates the performance. By using this technique, the noise is getting reduced and also we can get the originality of the image. The proposed filter gives suitable results on the basis of PSNR and MSE. Experimental results indicate that the proposed method performs significantly better than many other existing techniques. The proposed method is simple and easy to implement. As noise increases the proposed methodology works superior than other algorithms.

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