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A New Approach To Real Time Video Denoising using Temporal Video Slicing Frame Synchronization Technique

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Abstract: *Videos are frequently corrupted by various types of noise either during their process of capturing or during their transmission from one point to another point. In this paper we propose a novel approach for an efficient and improved quality real time video denoising using Temporal Video Slicing and Second generation wavelet transform like Dual tree complex wavelet transform (DTCWT).The Temporal Video Slicing (TVS) technique extracts discrete frames from a noisy video which will undergoes a process by DTCWT framework. The denoised frames are passed to the output instantaneously. This process is continued until all frames are denoised. All the denoised frames are suitably buffered to display the denoised video. Here the major core processing blocks are Video to frame conversion , DTCWT framework and Denoising.*
Keywords: *Frame synchronization, Temporal video slicing, Complex wavelet transform and Denoisng.*

I. Introduction

Digital videos play an important role in most of the applications such as satellite television, magnetic resonance imaging, computer aided Tomography as well as in areas of research and technology such as geographical information systems and astronomy. Videos are very often corrupted by noise either during their capture by the video sensors or during their transmission from one point to another point due to many of the reasons like internal imperfections of the capturing sensors, threats with the data acquisition process, poor illumination, atmospheric noises and interfering natural phenomena. In addition, noise can be introduced by transmission errors and compression[1].The ultimate goal of video denoising technique is to improve the degraded video in some sense by suppressing the random noise, which corrupts the video, while preserving the most important visual features of the videos[1-2].

A. Related work:

In the literature several video denoising algorithms and methods have been proposed, which are based on image denoising method i.e., video is converting into frames and frames are converting into images, finally denoising method applied on images. This is not a good solution to video denoising and also Most of the algorithms and methods use the smoothing or averaging process to attenuate the noise[3]. But due this smoothing process, while eliminating the noise components, in addition to the noise, some of the significant high frequency components of the image are also eliminated. This causes a significant information loss in the video and then after denoising, the quality of the video will become poor. This is a major drawback of the present generation [3]. In this paper we are mainly focusing on frame synchronization to reduce synchronization errors in various stages of video processing and implementation of DTCWT for video desnoising. In our approach video denosing is deployed on video frames not on images. This paper is organized as follows, Section-II gives noise and denoised concept, in Section-III frame Synchronization (TVS) explained, Section-IV gives information about DWT and DTCWT, Section-V deals with Implementation of proposed work, Section-VI gives results. Section-VII & Section-VIII gives conclusion and future work respectively.

II. Noise

Noise is a major source of video degradation in video processing. Noise is superimposed on video at various stages of video processing as shown in below.

a. Capturing the video at input side.
b. Video conversion.
c. Video transmission in channel.
d. Reconstruction of Videos.

A. Denoising:

It is process of removing the various noises imposed by above stages. Most of the researchers focusing video denoising at image level or Pixel level, which does not remove noise occurred at video to frame conversion or vice-versa. Frame synchronization is very important to removes flickering noise and other errors, which decides quality of video. In this paper we presented a Novel frame synchronization method to improve quality of real time video.

III. Frame Synchronization

A digital video is an ordered stream of frames. Frame synchronization is a very essential task , in order to stream the video in a proper sequence and to preserve its information integrity. If the frame synchronization is disturbed, it will straight away result in a change in the frame streaming order which will disturbs the information content of the video. In order to ensure the perfect frame synchronization and to preserve the significant video information, we employ a Temporal Video Slicing (TVS) technique for video-to-frame conversion.

A. Temporal Video Slicing:

Several conventional approaches are available for Video-to-frame and frame-to-image conversion and vice-versa. But the performance of all these approaches is not satisfactory as per as real time video processing is concerned. The proposed TVS technique samples the noisy video to obtain the discrete video slices or frames. All the sampled video slices or frames are numbered in order and stored in memory to synchronization and preserve the information. Temporal video slicing mechanism is shown in Fig.1.

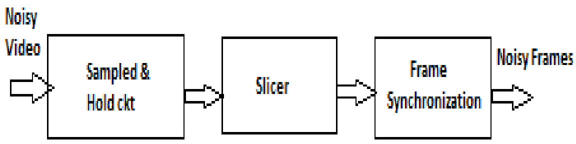

Fig.1: Temporal Video Slicing Process.

The main advantages of TVS approach is

a. Real time processing.
b. Single level processing.
c. Faster than existing methods.

For efficient use of the processor and to speed up the process, frame pipelining mechanism is implemented and the frames are processed in sequence. The proposed Frame Pipelining mechanism describes that the video frames are processed in sequence without any latency.

B. Temporal Video Reconstruction (TVR):

It is a reverse process if TVS, in TVR process the processed (denoised) discrete video frames are again reconstructed back to video in the same order as they were sampled from the input real time video sequences.

IV. DTCWT Framework

Wavelets give a superior performance in video denoising due to their positive properties such as sparsity and multi-resolution structure. With Wavelet Transform gaining popularity in the last two decades various algorithms for denoising in wavelet domain have been introduced [4].

A. Limitations of Discrete Wavelet Transforms:

In literature the standard DWT is a powerful tool, it has three major disadvantages that undermines its application for certain signal and image processing tasks [5]. The main disadvantages are described as below.

a. Shift sensitive.
b. Poor directionality.
c. Absence of phase information.

To overcome these limitations Dual-Tree Complex Wavelet Transform is introduced.

B. Dual Tree Complex Wavelet Transform:

The schematic process in central to a wavelet or sub band transform[6][7][8][9],is illustrated in below Fig.(2).The forward real wavelet tree makes an use of analysis filters $h_0(n)$ and $h_1(n)$,followed by subsampling,while the reverse transform first upsamples and then uses two synthesis filters $f_0(n)$ and $f_1(n)$.Where as the filter pair $\{g_0(n), g_1(n)\}$ and $\{p_0(n), p_1(n)\}$ constitutes the analysis and synthesis filter pairs[10] respectively for an imaginary wavelet tree with suitable sub sampling and up-sampling processes .The analysis and synthesis filter pairs[11][12] in one tree will differ with those in another tree with a half sample delay. The tree structure of DTCWT is shown in Fig-2.

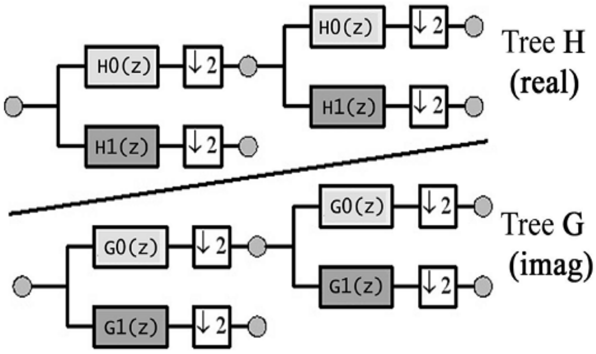

Fig.2: Analysis tree structure of DTCWT Framework.

$G_0(w) \simeq H_0(w)e^{-j\theta(w)}$;$\theta(w) = w/2$ (1)
And if $\varphi_r(t)$ and $\varphi_i(t)$ representing real and imaginary wavelets.Since the filters in both trees can be made to offset by half sample, the wavelets resulting from the filter pair satisfies the Hilbert transform condition, given as

$\Psi_i(W) \simeq \begin{pmatrix} -j\,\Psi_r(w); w>0 \\ j\,\Psi_r(w); w<0 \end{pmatrix}$ (2)
For real and imaginary trees, the modulation matrices [1] indicated by $M_1(z)$ and $M_2(z)$, respectively , be defined as
$M_{10} = \begin{pmatrix} F_0(z) & F_0(-z) \\ F_1(z) & F_1(-z) \end{pmatrix}$ (3)
$M_{20} = \begin{pmatrix} P_0(z) & P_0(-z) \\ P_1(z) & P_1(-z) \end{pmatrix}$ (4)
The condition for perfect reconstruction[13][14][15] can thus now be represented firstly in z-domain as for real
$H_0(-z)F_0(z) + H_1(-z)F_1(z) = 0$ (5)
$H_0(z)F_0(z) + H_1(z)F_1(z) = 2d^{-1}$ (6)

For imaginary

$G_0(-z)P_0(z) + G_1(-z)P_1(z) = 0$ (7)
$G_0(z)P_0(z) + G_1(z)P_1(z) = 2d^{-1}$ (8)

All the filters are assumed to be causal for simplicity and is the cause for introducing the term z^{-d}.secondly,$M_{11}(z)$ and $M_{21}(z)$ being the dual versions of $M_{10}(z)$ and $M_{20}(z)$ respectivel[13].We can write, for perfect reconstruction as
$M_{11}(z^{-1})^t M_{10}(z) = 2\boldsymbol{I}$ (9)
$M_{21}(z^{-1})^t M_{20}(z) = 2\boldsymbol{I}$ (10)
Where **I** being an identity matrix of order '2'.If all filters are FIR, then$M_{10}(z)$, $M_{20}(z)$ and $M_{11}(z)$, $M_{21}(z)$ belongs to GL(2;R[z,z^{-1}]).

Thus the wavelet transform does nothing else but sub sampling even and odd samples. This transform is generally called as a poly phase transfer [16]. The structure of DTCWT is shown in Fig-3.

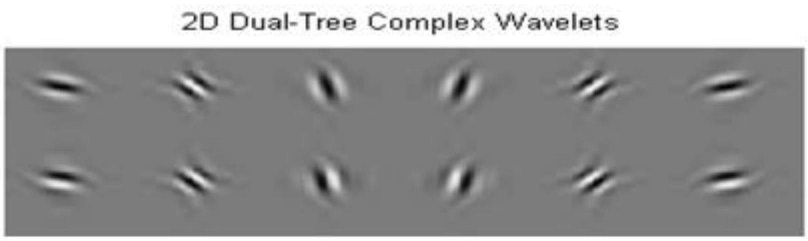

Fig.3: Dual tree complex wavelets structure [17].

V. Proposed work

In this paper we propose, and implement a novel approach for an efficient and improved quality real time video denoising using a DTCWT, a TVS and TVR techniques The overall schematic block diagram of the proposed approach is shown in below Fig-4.The proposed approach considers an original video which is corrupted by a random noise in, the noise degraded video file is forwarded to the video-to-frame conversion unit, which employs the TVS technique to convert the noisy video file into discrete noisy frames, which are numbered in sequence to preserve the synchronism as shown in Fig-5. According to this mechanism, during the first time slot $T_{1,}$ Frame-1 will be in DTCWT phase. During the time slot T_2,Frame-1 will be in Denoising Phase and Frame-2 will be in DTCWT phase and Frame-3 is about to fetch from memory. Next, in slot T_3,Frame-1 is in Inverse DTCWT phase,Frame-2 will be in denoising phase,Frame-3 will be in DTCWT phase and Frame-4 will be about to fetch from memory. Finally in slot T_4 ,Frame-1 completes its process, Frame-2 will be in Inverse DTCWT phase, Frame-3 will be in denoising phase,Frame-4 will be in DTCWT phase and Frame-5 is about to fetch from memory. Thus the proposed TVS technique provides an appropriate solution for video-to-frame conversion and synchronization during their process. All the processed video frames are buffered or combined in the same sequence that followed for forward process by Inverse TVS(which is a Temporal Video Reconstruction(TVR)process) technique to obtain the final processed video.

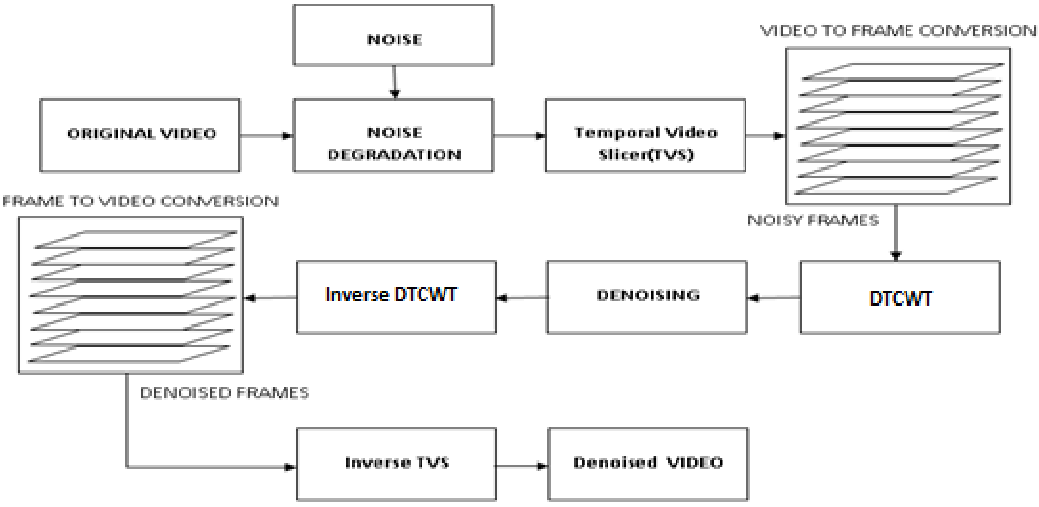

Fig.4: Overall schematic block diagram of the Proposed system.

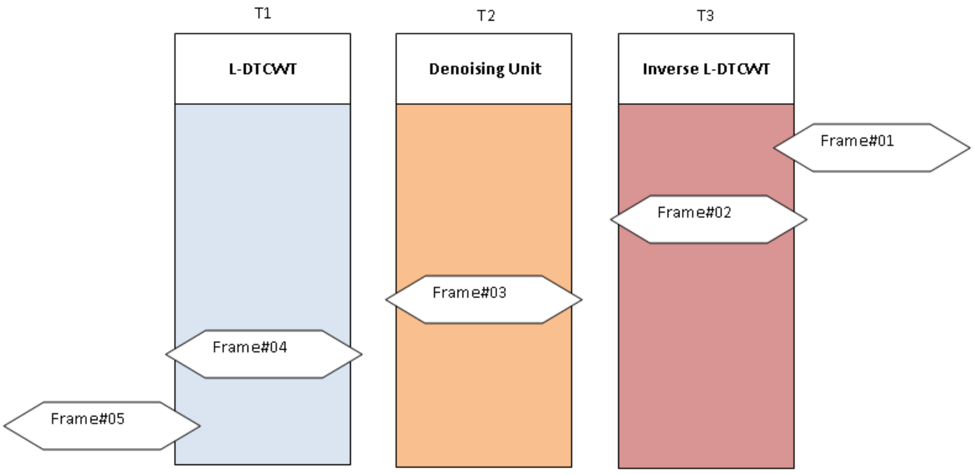

Fig.5: Synchronization of Video Frames in the proposed TVS technique.

VI. Results Analysis

We have successfully implemented our new approach for video denoising, in this first we took input video which is corrupted by noise and converted into sequence of frames using TVS approach, the denoised the frames using DTCWT and converted back to denoised video and obtained results were good from subjective side as shown in Fig-7, and Fig-6 and Table.1 show the transfer function of DTCWT and filter coefficients respectively.

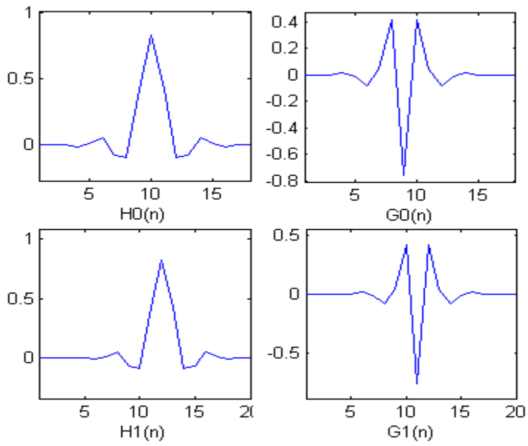

Fig.6: Transfer functions of DTCWT analysis filters.

$H_0(n)$	$H_1(n)$	$G_0(n)$	$G_1(n)$
0		0	0
0.0019	0	0	0
-0.0019	0	0	0
-0.0170	0	0.0019	0
0.0119	0.0144	-0.0019	0
0.0497	-0.0145	-0.0170	0.0144
-0.0773	-0.0787	0.0119	-0.0145
-0.0941	0.0404	0.0497	-0.0787
0.4208	0.4178	-0.0773	0.0404
0.8259	-0.7589	-0.0941	0.4178
0.4208	0.4178	0.4208	-0.7589
-0.0941	0.0404	0.8259	0.4178
-0.0773	-0.0787	0.4208	0.0404
0.0497	-0.0145	-0.0941	-0.0787
0.0119	0.0144	-0.0773	-0.0145
-0.0170	0	0.0497	0.0144
-0.0019	0	0.0119	0
0.0019	0	-0.0170	0
	0	-0.0019	0
		0.0019	0

Table.1: Analysis filter coefficients of DTCWT framework.

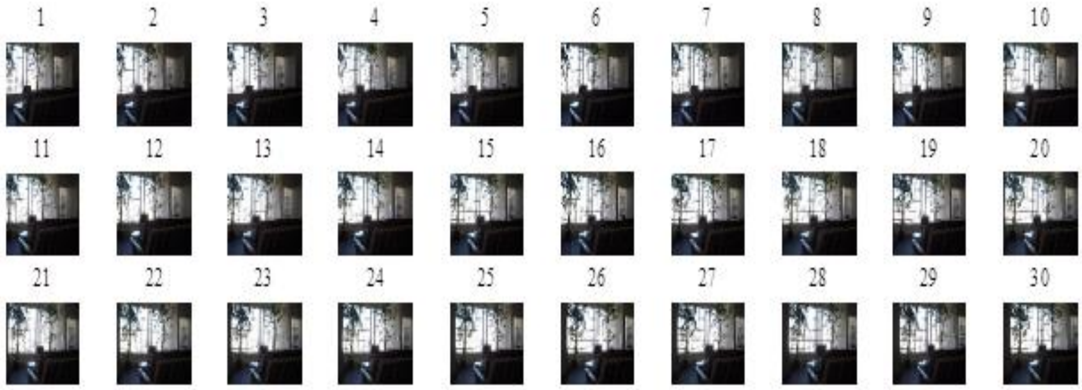

Fig.7: Video to Frame conversion and frame synchronization.

VII. Conclusion

In this paper we have proposed, implemented and tested a novel approach for an efficient and improved quality real time video denoising using a DTCWT. TVS technique was employed as a tool for video-to-frame conversion, frame-to-video conversion and also to maintain the necessary synchronization between the successive video frames extracts. The extracted noisy video frames are processed by DTCWT framework. This process is continued until all frames are denoised. All the denoised frames are buffered to display the denoised video. The proposed system is simulated in the MATLAB environment and obtained results are good comparatively existing method.

VIII. Future work

In this paper we have presented an approach for an efficient and improved quality denoising of the real time video sequences. This work can be extended further to reduce computational complexity and improve denoising block for better psycho-visual appearance.

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