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Performance of De-noising of video using E-RF3D filter using DST, DCT, Hadamard transform

Madhuri sahu[1], Pravin Patidar[2], A.C. Tiwari[3]
M. Tech. Scholar[1], Asst. Prof.[2], Prof. & HOD[3]
Department of Electronics and Communication Engineering, Lakshmi Narain College of Technology, Indore (M.P.) India[1, 2, 3]
Sahumadhuri73@gmail.com[1], pravinkpatidar@gmail.com[2], achandra0@gmail.com[3]

Abstract: *We have study a framework for the de-noising of videos which is jointly corrupted by random noise and fixed-pattern noise. Our approach is based on motion-compensated 3-D spatiotemporal volumes, i.e. a sequence of 2-D square patches extracted along the motion trajectories of the noisy video. It realize using following steps: 3D transformation of 3D group (grouping similar 2D image blocks into 3D data arrays which we call "groups") and then the coefficients of the 3-D volume spectrum are shrunk using an adaptive 3-D threshold array. Such array depends on the particular motion trajectory of the volume, the individual power spectral densities of the random and fixed-pattern noise, and also the noise variances which are adaptively estimated in transform domain. Simulation result is obtained by using DST, DCT, and Hadamard transform.*

Keywords: *Video De-noising, Spatiotemporal Filtering, Fixed- Pattern Noise, Adaptive Transforms.*

1. INTRODUCTION

Video quality enhancement is a long-standing area of research. As low-end imaging devices, such as web-cams and cell phones, become ubiquitous, there is ever more need for reliable digital image and video enhancement technologies to improve their outputs. Noise is dominant factor that degrades image quality. We focus on video de-noising in this paper. Our goal is to achieve an efficient, adaptive and high-quality video de-noising algorithm. DIGITAL videos may be degraded by several spatial and temporal corrupting factors which include but are not limited to noise, compression, blurring, ringing, blocking, flickering, and other acquisition. In this paper we focus on the joint removal of random and fixed pattern noise from a Video through spatiotemporal video filtering. Fixed pattern noise is the term given to a particular noise pattern on digital imaging sensors often noticeable during longer exposure shots where particular pixels are susceptible to giving brighter intensities above the general background noise. Random noise is a acoustic signal that consist of equal amounts of all frequencies.

Existing de-noising methods can be classified into reference-based (also known as calibration-based) or scene- based approaches. We study a scene-based de-noising framework for the joint removal of random and fixed-pattern noise. This framework, denotes that E-RF3D, is based on motion-compensated 3-D spatiotemporal volumes characterized by local spatial and temporal correlation, and on a filter designed to sparsify such volumes in 3-D spatiotemporal transform domain leveraging the redundancy of the data. [1]

2. VIDEO DE-NOISING

It is the process of removing noise from a video signal. Video de-noising methods can be divided into:

- Spatial video de-noising methods, where image noise reduction is applied to each frame individually.

- Temporal video de-noising methods, where noise between frames is reduced. Motion compensation may be used to avoid ghosting artifacts when blending together pixels from several frames.
- Spatial-temporal video de-noising methods use a combination of spatial and temporal de-noising. This is often referred to as 3D de-noising

The Spatial (2-Dimentional) and spatiotemporal (3-Dimentional) filters to remove the video noises. Spatial filters take only spatial information into account and as an effect can cause spatial blurring at high noise levels. This blurring effect can be reduced using both temporal and spatial information and the filtering performance can be improved at low noise levels. A pixel based spatiotemporal adaptive filter that calculates new pixel values adaptively using the weighted mean of pixels over motion compensated frames.

Types of filters used for de-noising-

- Mean Filtering

Mean filtering is a simple, intuitive and easy to implement method of *smoothing* images, *i.e.* reducing the amount of intensity variation between one pixel and the next. It is often used to reduce noise.

- Median Filter

The median filter is normally used to reduce noise in an image, somewhat like the mean filter. However, it often does a better job than the mean filter of preserving useful detail in the image.

- Gaussian Smoothing

The Gaussian smoothing operator is a 2-D convolution operator that is used to `blur' images and remove detail and noise.

- Frequency Domain

Frequency filters process an image in the frequency domain. The image is Fourier transformed, multiplied with the filter function and then re-transformed into the spatial domain.

3. JOINT NOISE REMOVAL FRAMEWORK

Noise removal is an elementary and pre-processing task in many image and video processing algorithms such as coding, compression, enhancement and target recognition. In this section, we describe the proposed RF3D framework for the joint removal of random and fixed-pattern noise. Data is corrupted by a combination of two spatially correlated components, i.e. random and fixed- pattern noise, each having its own non-flat PSD. The RF3D works as follows: First a 3-D spatiotemporal volume is built for a specific position in the video and then the noise standard deviations are estimated from a set of frames finally, the 3-D volume is filtered in spatiotemporal transform domain using adaptive shrinkage coefficients [1].

A flow chart of the framework is illustrated in Fig.

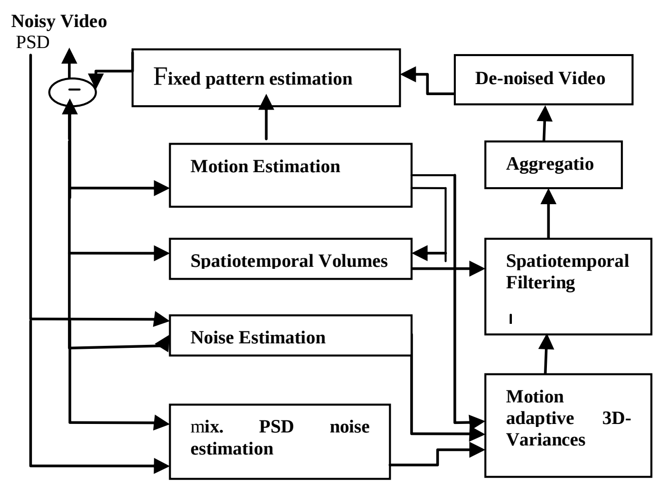

Fig. 1 Flowchart of random and fixed-pattern joint noise removal framework E-RF3D

3.1 Spatiotemporal Volume

The spatiotemporal volume is a sequence of 2-D blocks following a motion trajectory of the video. the analysis of spatial and temporal information, by constructing a volume of spatiotemporal data in which consecutive images are stacked to form a third, temporal dimension. The benefits of analyzing this volume are realized when the images are sampled sufficiently often such that there is continuity in both temporal and spatial domains [2]. One of the major advantages of this representation is that by analyzing feature structures in this volume, we may reason about much longer-term dynamics. Also, by conjointly providing spatial and temporal continuity, the complexity of feature correspondence is significantly reduced.

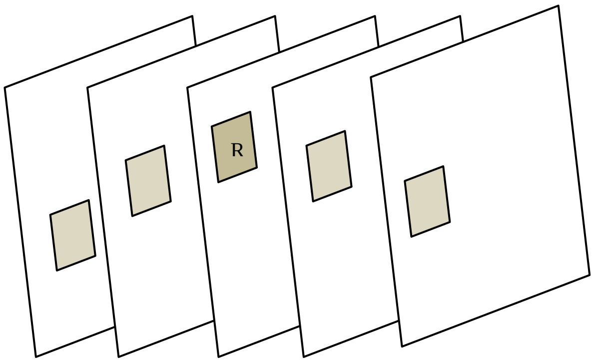

Fig. 2 Schematic illustration of a spatiotemporal volume. The blocks of the volume are grey with the exception of the reference block “R”

3.2 Spatiotemporal Filtering

Spatiotemporal video filters are used for the removal of noise from image sequence. This method combines the use of motion compensation and signal decomposition. Because of the object motion image sequence are temporally non stationary which requires the use of adaptive filters [3]. Natural signals tend to exhibit high auto correlation and repeated patterns at different location within the data, thus significant interest has been given to image de-noising and compression methods. For example, each pixel estimate is obtained by averaging all pixels in the image within an adaptive convex combination, whereas in self-similar patches are first stacked together in a higher dimensional structure called “group”, and then jointly filtered in transform domain. Three transform are used which are DCT,DST and HADAMARD.

- DCT- The discrete cosine transform (DCT) is a technique for converting a signal into elementary frequency components. DCT transform is used in signal and image processing. DCT transform have strong energy compaction property.
- DST- The Discrete Sine Transform (DST) is related to DFT and FFT. DST is used to represent signal in terms of a sum of sinusoids with its different frequencies and amplitudes.. To obtain DST of a digital signal, elements of the signal are reconfigured as an odd (anti-symmetric) extension of the input and then applying FFT. [4]
- Hadamard- The Hadamard transform is a fast transform and an example of a generalized class of Fourier transforms. The Hadamard transform as good to very good energy compaction for highly correlated images since no multiplication is required hadamard transform is faster than sinusoidal transforms. [5].

3.3 Motion Estimation and Compensation

In videos like news programs, there is very little change from frame to another. Video codes can take advantage of this property by only storing the differences from previous reference frames rather than storing the entire frame. This is implemented by doing motion estimation and compensation. Motion estimation (ME) is a process to estimate the pixels of the current frame from reference frame(s).Block matching motion estimation or block matching algorithm (BMA), which is temporal redundancy removal technique between 2 or more successive frames, is an integral part for most of the motion-compensated video coding standards. Frames are being divided into regular sized blocks, or so-called macro blocks (MB). [6].[9]

- I-Frames and P-Frames

Certain frames in a video are designated as key frames and these frames are not compressed. Such frames are called as “Intra frames” or “I-Frames”. For a macro block in the current frame, motion estimation tries to find the closest matching macro block in a previous reference frame(i.e. I-Frame) [10]. If the video does not contain any moving objects, then it is likely that the matching block also occur at the same position as the block in the current frame. Then the current block need not be stored fully, but only the difference in the pixel values (brightness and colour), from the matching block in the I-Frame is stored. Compression is achieved because difference numbers are much smaller than actual values. This difference vector that is stored is called as the "prediction vector". Such frames that are stored as differences from a previous reference frame are called as "P-Frames". The reference frame can be I-Frame or a P-Frame also, as long as it occurs before the frame. Considering that the video contains moving objects, the matching block in the reference frame might be at some other location as compared to the block in the current frame. Therefore, we need to specify a "motion vector" also, that specifies where the current block, with reference to the matching block is. Using the motion-vector and the prediction-vector of each block, we can reconstruct the entire P-Frame by knowing the pixel values in the reference frame.

- B-Frames

Video compression algorithms commonly encode frames in an order that is different from the order in which frames are displayed. The encoder may skip several frames ahead and encode a future frame. Then, it may go backwards and encode the next frame in the sequence. [7]

"B-Frames" are frames that are constructed by using both a previous frame and a future frame as a reference. The typical sequence of I-Frame, P-Frame and B-Frame is shown below:

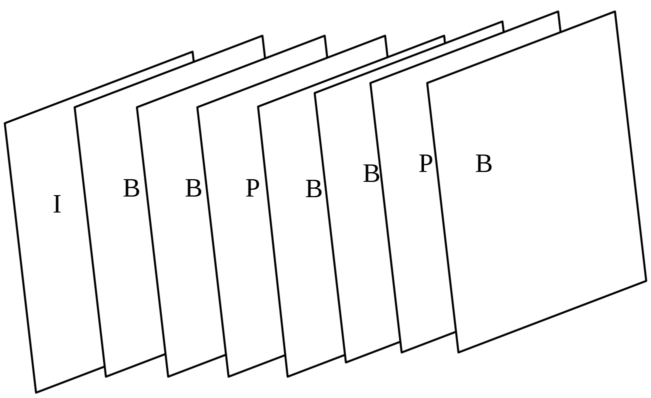

Fig. 3 Frame

4. SIMULATION RESULT

We obtained result by using E-RF3D filter with the three transform like DST, DCT, Hadamard. The filter tool is obtain from the [8]. The calculation parameters are PSNR and Threshold factor (lambada_3D). The result is obtained by using following parameters-.

TABLE 1 Parameters used

Parameters	***Value***
Noise	Gaussian
filter	E-RF3D
Transform	DST, DCT, Hadamard
Calculation parameter	PSNR and threshold factor(lambada_3D)
Simulation used tool	Matlab(R2014b)

TABLE 2
PSNR De-noising performance of E-RF3D

	PSNR		
lambada_3D	***DST***	***Hadamard***	***DCT***
1	27.55	27.43	27.82
3	30.21	30.49	30.68
5	29.65	29.97	30.29
7	28.34	29.63	30
9	27.34	29.51	29.86
11	27.03	29.41	29.82
12	26.93	29.33	29.77

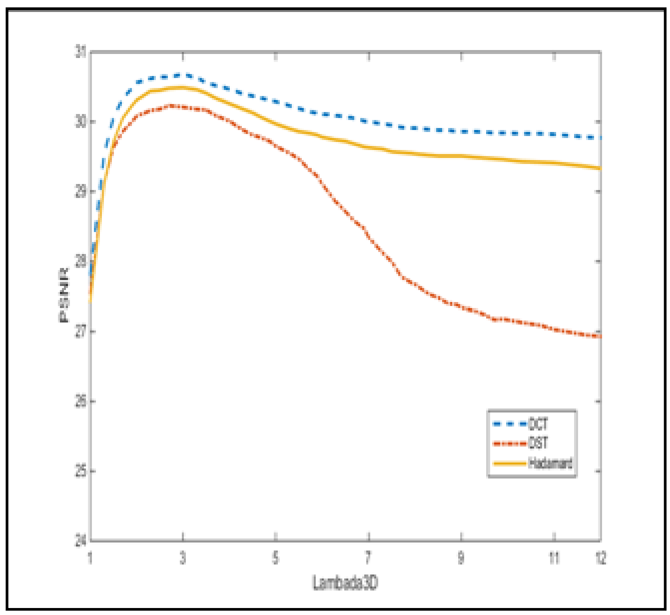

Fig 4. Performance of De-noising of video using E-RF3D filter using DCT, DST, Hadamard

5. APPLICATIONS

Video de-noising is highly desirable in numerous applications, including television broadcasting system, teleconferencing, video surveillance, restoration of old movies, object tracking, medical and astronomical imaging. Video signal are often distorted by noise during image acquisition or transmission. The corrupting noise might result in the degradation of visual quality of the images in the sequence and also affects the efficiency of further processing like compression and segmentation. Hence it becomes very essential to remove noise from video while preserving other important details such as edges and texture.

6. CONCLUSION

Video signals are often contaminated during acquisition and transmission. Video de-noising is the process of removing such distortions from a video signal. . A large amount of research in the area of image and video processing has been promoted by multimedia technology. The present techniques are very slow on processing and quality of de-noising is very poor for any real time applications like video conferencing and medical diagnosis. In this paper, we develop a noise removal algorithm for video signals in which spatial and temporal filtering approach is combined together.

The performance of algorithm is evaluated in terms of Peak Signal to Noise Ratio (PSNR). Experiment results show that the proposed algorithm gives higher PSNR from DCT transform as well as better visual quality.

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