DENOISING AND WATERMARKING: A SURVEY ON STATE OF THE ART TECHNIQUES

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ABSTRACT: Denoising has been one of the most innovative topics in image/video processing and security perspective in recent years, and is increasingly finding application in a wide range of modern communication systems. This paper begins with a brief overview of the basic characteristics of denoising and watermarking, and then concentrates on the most significant developments in the denoising and watermarking technology that have been made in the last several years. Emphasis is on the development of new algorithm for improved and secured video communication, and advances in the analytical modeling of video denoising and watermarking algorithms.

Keywords: Discrete wavelet transform (DWT), discrete cosine transform (DCT), discrete fourier transform (DFT), discrete shearlet transform (DST), singular value decomposition (SVD), peak signal to noise ratio (PSNR), mean square error (MSE).

I. INTRODUCTION

Video watermarking deals with security of digital data along with not disturbing the originality. In this approach digital watermark which may message, data, number, logo etc., embedded into digital content (audio, video, images or text) that can be retrieving later. Watermark mostly carries the copyright or ownership information of the content. As the use of internet is growing exponentially, it becomes the most useful means of communication for exchanging the information between the users across the world. The information may be in the form of multimedia content as image, audio and video. Hence secure and authentic transfer of these multimedia contents is a major issue.

Authentication is required to prevent theft, illegal alteration or illegal copying of digital contents, content labeling etc. Digital Watermarking is one of the most popular techniques used for this [7].

Mia Rizkinia et.al [8] author first calculates a linear feature over the spectral components of an M-channel image, which we call the spectral line, and then, using the line, we decompose the image into three components: a single M-channel image and two gray-scale images. By virtue of the decomposition, the noise is concentrated on the two images, and thus our algorithm needs to denoise only the two grayscale images, regardless of the number of the channels

N.Koteswara Rao et.al [21] proposed a “Two level DCT and wavelet packets denoising robust image watermarking”. In proposed method author obtained the higher robustness of embedding the watermark in low frequency. Robustness of the author’s proposed technique against many common attacks such as JPEG compression, additive Gaussian noise and median filter is evaluated & Compared with related works, author proposed method proved to be highly resistant in cases of compression and additive noise, while preserving high PSNR for the watermarked images.

Lingli Huang et.al [13] has proposed an improved weighted non-local means algorithm for image denoising. The non-local means denoising method replaces each pixel by the weighted average of pixels with the surrounding neighborhoods. Haijuan Hu et.al [22] has proposed “Removing mixture of gaussian and impulse noise by patch-based weighted means”. Based on the convergence theorems, authors propose a patch-based weighted means filter for removing impulse noise and its mixture with Gaussian noise by combining the essential idea of the trilateral filter and that of the non-local means filter.

Igor Djurovi´c et.al [2] has proposed “BM3D filter in salt-and-pepper noise removal”. Author applied the block-matching and 3D filtering (BM3D) scheme in order to refine the output of the decision-based/adaptive median techniques. Obtained results are excellent, surpassing current state-of-the-art for about 2 dB for both grayscale and color images. A. Jaiswal [24] has proposed “Image denoising and quality measurements by using filtering and wavelet based techniques”. In this paper author worked with denoising of salt & pepper and Gaussian noise.

Fumitaka Hosotani et.al [16] has proposed “Image Denoising With Edge-Preserving and Segmentation Based on Mask NHA”. Author proposes a zero-mean white Gaussian noise removal method using a high-resolution frequency analysis.

Qiang Guo et.al [5] proposed “An efficient SVD based method for image denoising”. The proposed method consists of three basic steps. First, our method classifies similar image patches by the block-matching technique to form the similar patch groups, which results in the similar patch groups to be low rank. Next, each group of similar patches is factorized by singular value decomposition (SVD) and estimated by taking only a few largest singular values and corresponding singular vectors. Finally, an initial denoised image is generated by aggregating all processed patches.

Zhao Jian et.al [9] has proposed: “Image Watermark Based on Extended Shearlet and Insertion Using the Largest Information Entropy on Horizontal Cone” . Rakesh Ahuja et.al [10] has proposed the “All aspects of digital video watermarking under an umbrella”. Ahmaderaghi et. al [18] presents a new perceptual watermarking model for Discrete Shearlet transform (DST). This property can be exploited on for watermark embedding to achieve the watermarking imperceptibility by introducing the human visual system using Chou’s model. Gurpreet Kaur et.al [27] has proposed a spatial domain method LSB for security of images.

Pratibha Sharma et. al [26] & Gou xin-ke et.al [30]: “ Digital image watermarking using 3 level discrete wavelet transform”. In this paper author presents digital image watermarking based on 3 level discrete wavelet transform (DWT) & compare it with 1 & 2 levels DWT. In this technique a multi-bit watermark is embedded into the low frequency sub-band of a cover image by using alpha blending technique. Aseem Saxena et.al [19] & Akhil Pratap Singh et. al [20] has proposed “Digital watermarking using matlab”. Digital Watermarking is a technique by which we can easily hide a message or important task, such as an image, song, video, data bits etc. behind another signal to increase its security and confidentiality.

Sangeeta Yadav et. al. [12] proposed “DCT based digital video watermarking using matlab/simulink”. Watermarking could be used to protect the authenticity of the owner. In this paper watermark is embedded in frequency domain and simulation results are carried out. Kalpana Bhelotkar et.al [30] has proposed “A survey of digital watermarking techniques and its applications”. Digital media is the need of a people now a day as the alternate of paper media. The aim of author is to provide a detailed survey of all watermarking techniques specially focuses on image watermarking types and its applications in today’s world.

Koyi Lakshmi Prasad et.al [1] has proposed “A hybrid LWT-DWT digital image watermarking scheme using LSVR and QR-factorization”. In this proposed article author presents an efficient and hybrid approach that integrates features of lifted wavelet transform (LWT) and discrete wavelet transform (DWT) based on linear support vector regression (LSVR) and QR-factorization for watermarking. Priya Porwal et.al [22] has proposed “Digital video watermarking using modified LSB and DCT technique”. Author proposes the least significant bit technique, discrete cosine transform technique, combined least significant bit and discrete cosine transform technique and least significant bit with modifications. S. G. Galande et.al [14] has proposed “Implementation of watermarking system to embed the information within video streams for security purpose”. In this paper, author combines DWT and DCT transforms to watermark data in video with minimum quality loss. Combined approach makes system robust as making use of multi-resolution DWT with energy compaction DCT. Results are evaluated for every frame in video by three parameters PSNR, MSE and NC. Mahesh Sanghavi et.al [29] has proposed “Efficient video watermarking in selected frames based on fibonacci series for ownership proof”.

Monasa Yengkhom et.al [15] has proposed “An analysis on digital watermarking in videos based on frequency domain techniques”. The combination of these techniques along with other techniques from different domain helped in enhancing the robustness. Some techniques could easily achieve robustness against certain attacks while some other on different attacks like geometric distortions, image processing attacks. Kaiser J. Giri et.al [25] has proposed “A robust color image watermarking scheme using discrete wavelet transformation”. In this paper author presents a secure and robust watermarking technique for color images using Discrete Wavelet Transformation.

Deepayan Bhowmik et.al [3] has proposed “Quality scalability aware watermarking for visual content”. The proposed algorithm generates scalable and robust watermarked image code-stream that allows the user to constrain embedding distortion for target content adaptations. The watermarked image code-stream consists of hierarchically nested joint distortion-robustness coding atom. R. Reyes et.al [32] & Deepayan Bhowmik et.al [4] “Digital video watermarking in DWT Domain Using chaotic mixtures” The proposed algorithm embeds a perceptually recognizable binary pattern, such as owner’s logotype. Firstly the video sequences are segmented by each scene, and then the binary watermark pattern is embedded into Discrete Wavelet Transform (DWT) domain of the randomly selected scene blocks. Xinshan Zhu et.al [28] proposed “Normalized correlation-based quantization modulation for robust watermarking”. The watermarked signal is produced to provide the modulated NC in the sense of minimizing the embedding distortion. The performance of the NC-based quantization modulation (NCQM) is analytically investigated, in terms of the embedding distortion and the decoding error probability in the presence of volumetric scaling and additive noise attacks. H. Sadreazami et.al [17] proposed “A robust multiplicative watermark detector for color images in sparse domain” In this brief, for the first time, a blind multichannel multiplicative color image watermarking scheme in the sparse domain is proposed. In order to take into account the cross correlation between the coefficients of the color bands in the sparse domain, a statistical model based on the multivariate Cauchy distribution is used.

II. DENOISING TECHNIQUE

During acquisition and transmission, images are inevitably contaminated by noise. As an essential and important step to improve the accuracy of the possible subsequent processing, image denoising is highly desirable for numerous applications, such as visual enhancement, feature extraction, and object recognition. The purpose of denoising is to reconstruct the original image from its noisy observation as accurately as possible, while preserving important detail features such as edges and textures in the denoised image.

In general, denoising algorithms can be roughly classified into three categories: 1) spatial domain methods; 2) transform domain methods; and 3) hybrid methods. The first class utilizes the spatial correlation of pixels to smooth the noisy image, the second one exploits the scarcity of representation coefficients of the signal to distinguish the signal and noise, and the third one takes advantage of spatial correlation and sparse representation to suppress noise.

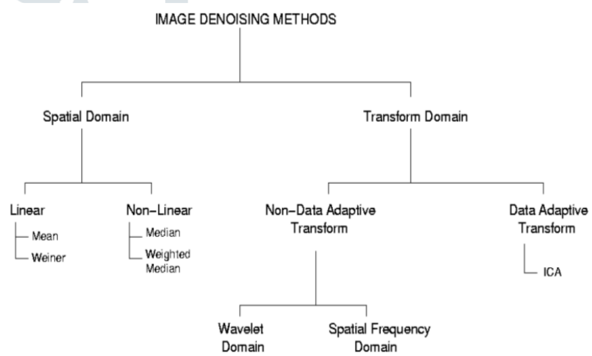

Figure 1 – Classification of Denoising Methods

There are different filtering techniques like averaging filter, median filter, Wiener filter, adaptive filter, etc. The median filter is one of the most popular nonlinear spatial filters for removing noise because of its good denoising effect and it is widely used to remove the salt and pepper noise only. Although it has good performance, but in case of other noise such as Gaussian noise they can produce a blurred and smoothed image with poor feature localization and incomplete noise suppression because median filter replaced the noisy pixel by a median value in their vicinity without taking into account the local features such as the presence of edges. Adaptive filter takes a moving filter window and estimates the statistical information of all pixels’ gray value, such as the local mean and the local variance. The central pixel’s output value is dependent on the statistical information. Adaptive filters adapt themselves to the local texture information surrounding a central pixel in order to calculate a new pixel value Adaptive filters present much better than low-pass smoothing filters, in preservation of the image sharpness and details while suppressing the Gaussian noise [24].

There are different wavelet thresholding approaches. The well-known technique of wavelet thresholding is hard and soft thresholding. In the hard thresholding techniques image is preserved if it is greater than the threshold; otherwise it is set to zero and in the soft thresholding technique image is shrunk to zero by an amount of threshold. The reconstruction using hard thresholding is smoother and more visually appealing than the one obtained using soft thresholding [24].

III. WATERMARKING TECHNIQUE

Watermarking algorithm just embeds a symbol, an image, video or anything in content so that it may be difficult to use by others without permission from the real owner. There are several techniques involved in watermarking but the important factors that should be kept in mind to achieve a good watermarking technique are robustness to any kinds of attacks, imperceptibility, and increase performance without destroying the real content, increase fidelity aspects, key restrictions tamper resistance and should give good performance in maintaining real time applications [15].

Video watermarking is the major research field to embed the watermark inside the video and safe the originality of the video. It inserted the watermark into video in a way which can't be finding out by the human eyes. Watermark is embedded into video by two methods visible (logo or name) which can be easily detected by human eyes, for e.g. music album with singer name or company logo and invisible watermarking which can't be detected by a person eyes and follow the procedure of embedding and extraction algorithms [11].

For digital watermarking, another criteria for watermarking classification is the domain in which watermark is embedded i.e. spatial domain or frequency domain. In spatial domain, watermark embedding is done by directly modifying pixel values of an image. In frequency domain watermarking, image is first transformed into its frequency components and then appropriate frequency components are selected for embedding watermark. Recovering embedded watermark from watermarked image is called as watermark extraction [11].

3.1. Watermarking Types:

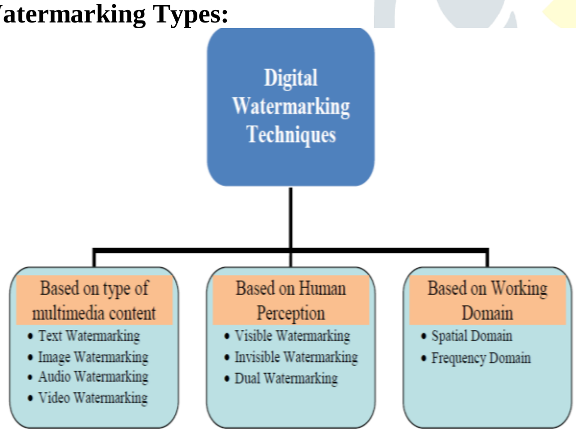

Figure 2: Digital Video Watermarking Techniques

3.1.1 Visible Watermarking Watermarks are applied to images only. These watermarks can be seen and they cannot be removed by just cutting out the watermark. They are protected from statistical analysis [27]. The only disadvantage of visible watermark is it degrades the image quality. It is not possible to detect them by dedicated programs or devices.

3.1.2 Invisible Watermarking These watermarks are not visible and they can be removed only by the authorized user. They are used by authors and content protectors as they help in protecting the content from being copied.

3.1.3 Dual Watermark The partially visible watermark is a combination of a visible watermark and an invisible watermark. First a visible watermark is inserted in the host image and then an invisible watermark is added to the already visible-watermarked image [26].

3.2. Spatial Domain Scheme

In the spatial domain, watermark bits are directly replaced into the pixels of one or two arbitrarily selected part of a frame and are updated based on perceptual analysis of video frames. Embedding the watermark by spatial domain scheme is broadly classified in two categories as follows:

3.2.1. Least Significant Bit (LSB)

A simplest way is to replace the least bit of each selected pixels of an image or video, represented by 8 bits, with the watermark bits. Converted the encrypted watermark into the binary form to be placed into the LSB position of selected position of pixels of each frame.

3.2.3. Spread Spectrum (SS)

Another scheme for embedding the watermark is to spread the watermark in the following fashion. In this scheme, message as watermark (W) is encoded to generate a noise like sequence and this sequence is added to the original host data i.e. video or video clips. Since no mathematical transformations are applied therefore such scheme is computationally more efficient as compared to other transformation scheme described in the next section [10].

Spatial domain watermark are created by just altering some of the pixels in the media. Watermark is embedded into the original image in spatial domain, dividing the original image into different sizes of block and by adjusting the brightness of the block according to the watermark embedded. It is easier to implement but cannot achieve robustness. Whereas, Frequency domain watermarks are obtained by modifying the transform coefficients of the frames contain in videos. Commonly used Transform domain methods are: DCT, DWT, and DFT [23].

3.3 Frequency Domain

In this technique, host image is initially converted into frequency domain by using the method of transformation like the discrete wavelet transforms (DWT), discrete cosine transforms (DCT) or discrete Fourier transforms (DFT). The transform domain coefficients are then modified using the watermark. The inverse transform is applied to obtain the image watermarked finally. Due to complicated calculations done by the forward and inverse transforms, these methods are more complex and have higher computational costs compared to spatial domain methods. Transformation domain methods however are more robust enough against attacks compared to spatial domain methods.

Commonly used Transform domain methods: -
DCT - Discrete Cosine Transform.
DWT - Discrete Wavelet Transform.
DFT- Discrete Fourier Transform [23].

3.4. Watermark Requirements

Some general requirements, not necessarily met by all the watermarking schemes are as:

1. Perceptual Transparency: The watermark embedded must not affect the quality of underlying host image so that the user cannot distinguish the original image from the watermarked one. The watermarked image must replace the original one for all practical purposes
2. Data Payload: The total quantity of information stored as watermark within the host image, this depends on the application under consideration.

3. Robustness: The embedded watermark must confirm to different attacks such as compression, scaling, rotation, cropping and noise etc.
4. Security: Watermark embedded must be resistant to attempts by attackers to destroy or remove without modifying the cover data itself.
5. Effectiveness: The extraction process of embedded watermark must be fast and simple.

IV. PROPOSED ALGORITHM

A. WATERMARK EMBEDDING:

Consider an original color video **X** of size N1 X N2. Without loss of generality, **X** is partitioned into *n* non-overlapping frames **X1**, X2, X3,………..,**Xn-1**, where the size of each frames is N1 X N2 and *N* is a positive integer power of 2. The 2-D DWT is applied to each frames to obtain the DWT counterparts F{1},F{2}, F{3} ;: : : ; F{I_n} of dimension M x M. The wavelet decomposition of image/frames is performed by splitting it into 4 sub bands, namely the HH, HL, LH, and LL sub bands. The HH sub band gives the diagonal details of the image; the HL sub band gives the horizontal features while the LH sub band represents the vertical structures. The LL sub band is the low resolution residual consisting of low frequency components and it is this sub band which is further split at a higher level of decomposition. The low pass filters represent the ‘‘approximation’’ of the signal or its dc component and the high pass filters represent the ‘‘details’’ or its high frequency components.

B. DENOISING WATERMARKED VIDEO

Most common attack on the watermarked video is noise. The corrupted video by noise may be given as:

Z(i.j) = Y(i,j) + n

Where Z is the corrupted video, Y is the watermarked video & n is the AWGN noise

If any type of noise appeared in watermarked video in any wireless medium than filtering method with thresholding based DWT technique is used to remove that noise.

CASE I: Apply the Some linear & non-linear filtering i.e. MF (median filter), AWF (adaptive wiener filter) is applied on noisy input and results have been observed in terms of PSNR & Visuality. If $(PSNR)_{med} > (PSNR)_{wien}$ then output of median filter is again denoised by thresholding based DWT technique. If $(PSNR)_{med} < (PSNR)_{wien}$ then output of adaptive wiener filter is again denoised by thresholding based DWT technique. So that noise in the image can be removed and finally the denoised image is obtained.

CASE II: Also Check the Visuality. If the Visuality is poor than starts from original noisy image/frames and denoised by Adaptive Median Wiener filter (AMWF) uses varying window size to noise reduction technique. Size of window increases until correct value of median is calculated. Adaptive filter estimates the statistical information of all pixels' gray value, such as the local mean and the local variance. After that output of AMWF is again denoised by thresholding based DWT technique. Finally denoised image is obtained.

C. WATERMARKING EXTRACTION

The watermark extraction process is the inverse procedure of the watermark embedding process. The proposed algorithm is a non-blind algorithm so the original video sequence is required. The watermarked (and may be attacked) video is divided into frames. The watermark is extracted using the following equation:

$$W' = Y(i,j) - X_L(i,j) / \alpha$$

Where W′ is the extracted watermark and **Y** is the watermarked sub-band (and may be attacked). After the extraction process, multiple copies of each block of the watermark are obtained; the watermark block is recovered by averaging the watermarked blocks extracted from the same frame to reduce the attack effects. Finally, all the blocks are combined together to produce the recovered watermark.

TABLE 1: ANALYSIS OF VIDEO DENOISING WITH WATERMARKING TECHNIQUES IN SPATIAL & FREQUENCY DOMAIN

S.NO	AUTHOR'S	EXISITING ALGORITHM	YEAR	PURPOSE	PERFORMANCE PARAMETER
1.	Koyi Lakshmi Prasad et.al [1]	A Hybrid LWT-DWT Digital Image Watermarking Scheme using LSVR and QR-factorization	2016	Image watermarking	PSNR, MSE
2.	Igor Djurovi´c et.al [2]	BM3D filter in salt-and-pepper noise removal	2016	Image denoising	PSNR, MSE
3.	Deepayan Bhowmik et.al [3]	Quality Scalability Aware Watermarking for Visual Content	2016	Watermarking	PSNR
4.	DEEPAYAN BHOWMIK et.al [4]	Visual Attention-Based Image Watermarking	2016	Image watermarking	PSNR, MSE
5.	Qiang Guo et.al [5]	An Efficient SVD Based Method for Image Denoising	2016	Image Denoising	PSNR
6.	Salwa A et.al [6]	Multiresolution Video Watermarking Algorithm Exploiting the Block-Based Motion Estimation	2016	Video watermarking	PSNR, MSE
7.	Gabriela Ghimpe¸teanu et.al [7]	A Decomposition Framework for Image Denoising Algorithms	2016	Image denoising	PSNR
8.	Mia Rizkinia et.al [8]	Local Spectral Component Decomposition for Multi-Channel Image Denoising	2016	Image denoising	PSNR
9.	Hamidreza Sadreazami et.al [17]	Multiplicative Watermark Decoder in Contourlet Domain Using the	2016	Image watermarking	PSNR, BER

		Normal Inverse Gaussian Distribution			
10.	Zhao Jian et.al [9]	Extended Shearlet transform.	2015	Image watermarking	PSNR, MSE, BER
11.	Sharanjeet Kaur et.al [11]	3rd Level DWT & SVD Based Video Watermarking	2015	Video Watermarking	PSNR, MSE
12.	Sangeeta Yadav et. al [12]	DCT Based Digital Video Watermarking	2015	Video Watermarking	PSNR, MSE
13.	Lingli Huang et.al [13]	Improved Non-Local Means Algorithm for Image Denoising	2015	Image denoising	PSNR, MSE
14.	Monasa Yengkhom et.al[15]	Digital Watermarking in Videos based on Frequency Domain Techniques	2015	Video watermarking	PSNR, MSE
15.	Fumitaka Hosotani et.al [16]	Image Denoising With Edge-Preserving and Segmentation Based on Mask NHA	2015	Image Denoising	PSNR
16.	Hamidreza Sadreazami et.al [17]	Multiplicative Watermark Decoder in Contourlet Domain Using the Normal Inverse Gaussian Distribution	2016	Image watermarking	PSNR, BER
17.	ASEEM SAXENA et.al [19]	DWT WITH 7 LEVEL Encryption & decryption	2014	Image watermarking	PSNR, MSE
18.	AKHIL PRATAP SINGH et.al[20]	DWT alpha bending	2014	Image watermarking	PSNR
19.	N.Koteswara Rao et.al [21]	DCT & wavelet packet	2014	Image watermarking	PSNR, NCC
20.	Haijuan Hu et.al [22]	Removing Mixture of Gaussian and Impulse Noise by Patch-Based Weighted Means	2014	Image denoising	PSNR, MSE
21.	Jaiswal A [24]	Image denoising by using filtering and wavelet based techniques	2014	Image denoising	PSNR, MSE
22.	Kaiser J. Giri et.al [25]	Color Image Watermarking Scheme Using Discrete Wavelet Transformation	2014	Image watermarking	Accuracy rate
23.	Gurpreet Kaur et.al [27]	DWT-LSB	2013	Image watermarking	PSNR
24.	Xinshan Zhu et.al[28]	Normalized Correlation-Based Quantization Modulation for Watermarking	2014	Image watermarking	BER, PSNR
25.	Gou xin-ke et.al [33]	Digital Image Watermarking Based on DWT	2011	Image watermarking	PSNR, MSE
26.	Wang-Q Lim et.al [34]	The Discrete Shearlet Transform : A New Directional Transform and Compactly Supported Shearlet Frames	2010	Discrete shearlet transform	PSNR
27.	R. Reyes et.al [35]	Digital Video Watermarking in DWT Domain Using Chaotic Mixtures	2010	Video Watermarking	PSNR, NC

IV. CONCULSION

This paper has leads us to resolve two major issues of recent development in video processing: new techniques of video denoising for improved performance, and recent advances in video watermarking techniques. A comprehensive list of references has been given, but this is like a drop of ocean in respect of work on video processing by researchers all over the globe. Thus one of the main topics in this survey has been the research and development in recent years that has gone toward improving the performance of the video

Several techniques have been surveyed in Table 1 in terms of their application area and performance parameters and it is concluded there is a need to develop a technique which may simultaneously work to preserve the originality as well as security. Towards the final remark two techniques are proposed one for denoising of video in terms of increased PSNR and lowest MSE, another for security in terms of watermark embedding along with parameters like robustness, imperceptibility and payload.

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