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Design of Quality Improvement Technique Through Ridgelet Transform on Watermarked Video

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ABSTRACT: with the rapid spread of the use of video files cross the world before and during the pandemic, and the availability of capabilities and tools to create, store and transmit video files of high quality. The latest studies illustrate that video files are the highest data types that had been transmitted over the internet, during video transmission or broadcast from one point to the other or over the internet, videos may be damaged for several reasons, such as packet loss or jitter, in this paper, a proposed approach of Ridgelet transformation is presented to improve received video file quality, based on embedded watermark quality present in video frames. It is implemented by extracting three-color channels of video frames, i.e., Red (R), Green (G), and Blue (B). A selected watermark is included in blue channel (B) along with transmitting the video file from source to destination. However, the quality of watermark is measured with execution regarding watermark. Peak Signal-to-Noise Ratio (PSNR) and Mean Square Error (MSE) were adopted as measurement criteria. The evaluation results show interesting comparative values without noise, in comparison to applying salt, pepper, and Gaussian noise to video frames.

Keywords: Ridgelet Transform, Video Quality, Watermark, Color Channels.

1. INTRODUCTION

Nowadays, video files are stored in a digital form within the databases of servers, from where they are transmitted through internet using communication networks. Such files are subjected to different distortions throughout various phases such as acquisition, compression, type conversion, and transmission. Due to the rapid evolution of communications over internet and mobile networks, the quality of transmitted videos has become an important criterion. Many real-time applications require video processing and transmissions, such as video on demand applications, e.g., Netflix, Hulu, Vudu, video conferences, online meetings, and e-learning sessions. Therefore, video files are getting the most preferable data type nowadays, especially video games and movies [1],[3].

The quality of images or video is one of the main concerns in visual data, that is being enhanced over the years. There are two main approaches in evaluating the quality of videos or images, namely subjective quality and objective quality metrics. The subjective quality metrics depend on the opinion of several experienced individuals (observers) to determine video quality; observers determine either quality video files or impairment assessments. The objective quality metrics rely on methods and procedures to determine video file quality [2],[4].

Objective quality metrics are classified into three schemes: no-reference metrics (NR), reduced reference metrics (RR), and full reference metrics (FR) [5].

The metrics of FR scheme requires, availability of actual video along with degraded file together to calculate quality of video. Peak Signal-to-Noise Ratio (PSNR) and Mean Square Error (MSE) are the most well-known examples of full references method [6].

Reduced reference metrics (RR) scheme does not require the reference video file. But only limited amount of its data will be used with the degraded version of video file to evaluate received video quality [7],[9].

The **no-reference metric (NR)** does not contain a copy or part of original video, whereas it contains received video only. Thus, quality measurement becomes more difficult. Instead, human observers can rate video quality using eye observation [10], [11].

In this paper, we propose a model using Ridgelet transformation with watermarking, evaluating embedded watermark quality to determine the received video file's quality.

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The authors in [12] proposed a system to enhance watermarking by extracting the Principal Component (PC) which is obtained by applying discrete wavelet transform to original image. Hence obtaining four sub-bands, while singular value decomposition (SVR) is applied to each sub-band. A scrambled watermark is added to the obtained pc of scrambled image. By using an artificial bee colony; the host image and watermark quality are measured. Results shows more than 0.9 of structured similarity index (SSIM) and higher than 30 dB of PSNR are considered as good quality for Human Visual System (HVS).

In paper [13], a no-reference quality metric was proposed using video watermarking, applying 8x8 Haar and Daubeche (D4) transformations. They were successful in evaluating the quality of received video file by applying multiple types of noise such as salt, pepper, and Gaussian filters, in addition to the JPEG compression technique. Experimental results illustrate that, the testing accuracy of suggested scheme was 6% for Haar and 5% for D4, whereas the accurate ratio was 94% for Haar and 95% for D4.

In paper [14], Visible watermarking algorithms were investigated. Various assessment metrics were proposed, e.g., global visibility, local and global obtrusiveness. Within original image, a global quality of watermarked images and edge regions were computed using two criteria with pixel-based just-noticeable distortion (JND) function and human visual system (HVS). Experimental results showed an adequate performance of proposed metrics for assessment of all watermarking algorithm types, providing reliable numerical assessment values.

In paper [15], the authors proposed a new model of watermarking framework to protect image processing models. To this end, they proposed a spatial invisible watermarking technique. Particularly, setting a black-box target model. An invisible and conjoined watermark was embedded in its outputs. The proposed system decreased vulnerability, providing good protection for valuable data by embedding watermarks to their labeled images.

RIDGELET Transform is a powerful transformation that was introduced by Donoho in 1998. Ridgelet can be calculated either from 1D wavelet transforms that are oriented with lines and radial directions. It can be calculated in two steps; the first step computes discrete Radon transform; the second step deals in applying a wavelet transform to the output, as described in equation 1[16]-[18].

$$CRT_f(a,b,\theta) = \int Rf(\theta,t)a^{-\frac{1}{2}}\Psi\left(\frac{t-b}{a}\right)dt \qquad (1)$$

Where a, b, and θ denotes coefficients of Ridgelet transform, θ € [0,127], $\boldsymbol{\Psi}$ denotes the ridgelets generated from transformed image, t and R refers to radon transformation.

The finite radon transform (FRAT) are calculated consisting of two phases: first, calculate radon transform (RA) which is an integral function over straight lines [19], [20].

Radon transformation can be calculated by applying 1D inverse fast Fourier and 2D fast Fourier transform (FFT) to every existing 32 radial direction of projections at radon. Resulting radial directions will be applied with origin three levels of decompositions, whereas a 1D wavelet transform is applied, as described in equation 2 [21], [22].

$$Rf(\theta,t) = \int f(x_1,x_2)\, \delta(x_1 \cos\theta + x_2 \sin \sin\theta - t)dx_1dx_2 \qquad (2)$$

Where θ is transformation angle, t is transformed image.

Figure 1 illustrates the relationship between Radon and Ridgelet schemes using Fourier or wavelet transformations.

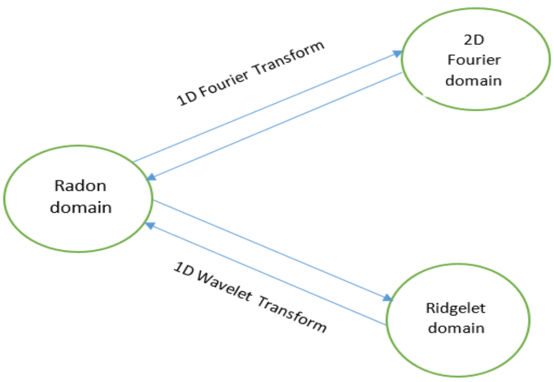

FIGURE 1. - Relationship between Radon and Ridgelet schemes using Fourier or Wavelet Transformations [23]

2. THE PROPOSED SYSTEM

The proposed system computes the quality of transmitted video using FR objective metric based on quality of extracted watermark from received video file. This objective is implemented in four stages.

2.1 Frame Extraction and Conversion Phase

In the proposed system, first step involves extracting frames from video that is to be transmitted, embedding the watermark with pre-selected frame; then R, G, B channels are extracted from selected frame using the equations 3,

$$B = \frac{\int E(\lambda)\, b(\lambda) d\lambda}{255},\ R = \frac{\int E(\lambda)\, r(\lambda) d\lambda}{255},\ G = \frac{\int E(\lambda)\, g(\lambda) d\lambda}{255} \quad (3)$$

Blue channel is selected to include the watermark with its pixels' values in proposed system. Figure 2 explains frame extraction and watermark embedding process. Selected channel i.e., the blue channel in system, is converted to Ridgelet domain using equation (1).

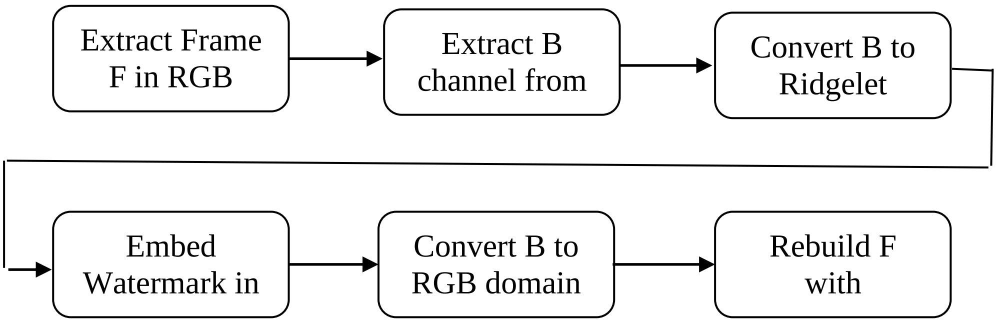

FIGURE 2. - Watermark embedding process

Then the selected channel, which is the Blue channel in the system, is converted to Ridgelet domain using equation (1) mentioned above.

2.2 Watermark Embedding Phase

The second step in proposed system is, including the selected watermark to extracted blue channel (B), after converting B into Ridgelet domain. Figure 2 illustrates step A and B of proposed system.

The watermark is embedded accordingly, specifically in the high quarter of transformed blue channel within the Ridgelet domain. The last step of Ridgelet domain transformation is applying 2D wavelet transform to the selected frame. Fig. (3) shows embedded watermark position in transformed blue channel within (HH) quarter, whereas actual picture was subjected to filtration using high-pass, providing 3 images as the output. Every image describes localized deviation in accordance to brightness (in detailed) of actual imagery. This was consequently downscaled after subjecting it to low – pass filtration process, providing an approximated picture as outcome in yielding image approximation within upper-left portion, where watermarking will get embedded.

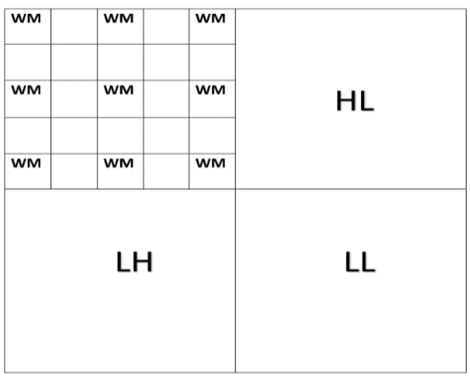

FIGURE 3. - Watermark spread over the transformed blue channel

The watermark used in the proposed system is a black and white 52×52 Lena image as shown in figure 4; the size has been used specifically to get embedded in video frame as Ridgelet technique requires an N×N input image.

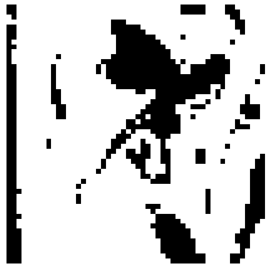

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FIGURE 4. - Embedded Lana watermark in video frame

The adopted watermark embedding technique in proposed system is the least significant bits (LSB). Following the extraction of video frames and selection of a specific frame (F) before the watermark insertion process. The watermark bits are embedded in second last bit of blue channel's (B) pixels' values of extracted frame (F). However, we need a resizing operation to transform the N×M frame to N×N. To finalize this step of applying Ridgelet method, it is mandatory to reconstruct video files and transmit it to targeted destination.

Accordingly, after addition of watermark to the selected frame, inverse Ridgelet will be applied on blue channel B using equation 4,

$$R-1[\tilde{f}](x,y)=\sum \quad \lambda\in\Lambda \sum \quad t\in T\lambda \quad \tilde{f}(\lambda,t)\psi\,\lambda\,(x-tx,\ \ y-ty) \tag{4}$$

Where x,y denote pixels location, in B within the Ridgelet domain B and T are ridgelets. The frame is reconstructed with its location in the video file before it is transmitted to destination.

2.3 Watermark Extraction Phase

The process of watermark extraction is similar to that of watermark embedding, when the video file reaches its destination, as shown in figure 4.

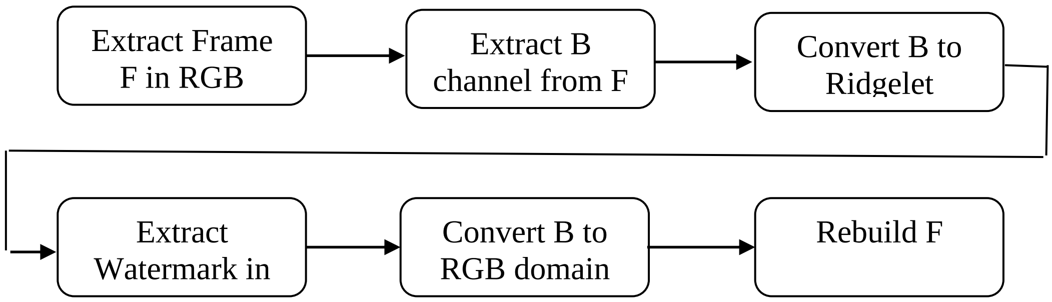


FIGURE 5. - Watermark extraction process

Furthermore, frames are extracted again; the next step is to repeat obtaining the R, G, and B channels from extracted frame using equation 1. The B channel is converted with embedded watermark out of Ridgelet domains in RGB area, using inverse Ridgelet transformation in equation 4. Consequently, watermark is extracted and examined for any degradation.

2.4 Quality Assess Phase

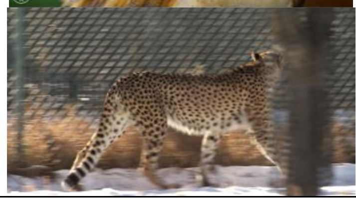
Quality measurement methods, e.g., MSE and PSNR are applied to watermark and video frames. To compute and compare the embedded watermark in comparison to that of original frame and watermark. Thus, ultimately computing degradation of transmitted video file.

3. EXPERIMENTAL RESULTS

The proposed system is applied to several high-quality video files, by examining validity of such systems in achieving targeted objectives. It has been proven that the selected frames containing watermark has preserved their quality, even though watermark is invisible to the human visual system (HVS).

The videos used in testing the proposed system belongs to open-source Waterloo dataset [24] which is available for public use; video's properties are shown in table 1.

Table 1. - Videos' properties

Video	Duration	Frame size	fps	sample
BigBuckBunny	10 s	1920 x 1080	30	
LOR	30 s	1920 x 1080	30	
BirdOfPrey	10 s	1920 x 1080	30	
Cheetah	11 s	1920 x 1080	30	

The experimental results shows, that with the case of noise-free assumption, watermark was recovered 100%.

The results of proposed system are shown in table 2 and table 3, addressing the comparison of video file transmission with and without noise. The applied types of noise were Salt, Pepper, and Gaussian. These consisting of various levels, stating their effect on watermark as well as video frame vulnerability to such types of noise.

As shown in table (2), quality of the extracted watermark without any file jamming is 100%, and the pattern in which it is gradually reduced in case of salt, pepper, or Gaussian noise and impact on selected frames of transmitted video file.

Table 2. - PSNR and MSE for watermark with and without noise influenced

Video	Conversion time in seconds	Extract without noise		Salt and peper						Gaussian			
				0.002		0.02		0.09		0.4		0.9	
		PSNR	MSE	PSNR	MSE	PSNR	MSE	PSNR	MSE	PSNR	MSE	PSNR	MSE
BigBuckBunny	0.85	Inf	0	82.4	0.003	68.8	0.008	62.6	0.04	56.1	0.16	59.8	0.07
LOR	0.86	Inf	0	82.4	0.003	69	0.01	63.4	0.03	56	0.16	60.1	0.06
BirdOfPrey	0.86	Inf	0	76.4	0.001	69.4	0.1	62.3	0.04	57.33	0.12	59.7	0.07
Cheetah	1.19	Inf	0	82.4	0.001	69.9	0.01	62.5	0.03	57.1	0.13	inf	0

Table 3 depicts transmitted video quality measurement. It shows that, despite no noise inflection occurrence with the transmitted video, there is still some quality degradation. This occurs due to image resizing that is required during Ridgelet transmission. Before applying such transformation as the Ridgelet transformation works with N×N image size only, however, the video frame size is N×M. The selected video files in this paper are high-definition (HD) with a 16:9 aspect ratio of the image.

Table 3. - PSNR and MSE for frame with and without noise influenced

Video	Without noise	Salt and Pepper	Gaussian

			0.002		**0.02**		**0.09**		**0.4**		**0.9**	
	PSNR	**MSE**	**PSNR**	**MSE**	**PSNR**	**MSE**	**PSNR**	**MSE**	**PSNR**	**MSE**	**PSNR**	**MSE**
BigBuckBunny	28.9	85.8	28.7	85.5	28.2	85.4	28.8	85.2	28.8	85.7	28.9	86
LOR	29.1	79.8	29.1	79.9	29.1	79.8	29.14	79.91	29.1	80.1	29.1	80.2
BirdOfPrey	29.1	80.18	29.12	80.1	29.13	80.1	29.13	79.9	29.11	80.3	29.1	80.6
Cheetah	27.3	120.6	27.3	120.62	27.35	120.6	27.36	120.4	27.3	120.9	27.3	121.4

4. CONCLUSION

Experimental results of the proposed system had proved system validity in preserving quality of retrieved watermark. The Ridgelet transform coefficients were utilized in embedding selected watermarks information bits. Outcome had demonstrated, privileges regarding Ridgelet transformation technique, achieving non-degradation performance, thereby maintaining quality of image size to N×N. However, a small percentage of degradation occurs on frame quality carrying watermarks due to number of transformation operations of Ridgelet method and required video frame resizing to include watermarks. The selected videos in this paper are HD qualified. The watermark embedded in Ridgelet domain is invisible to HVS system. Moreover, it is proven that the watermark was retrieved without distortion, whenever the video file was received without impairment. However, when noise is applied to transmitted video, some quality degradation was observed in watermark and video quality. To this end, we recommend applying the said proposed system to YCBCR domain.

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CONFLICT OF INTEREST:

Author declare no conflict of interest

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