Video Watermarking Using Discrete Wavelet Transform And Singular Value Dicomposition

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Abstract: **Digital Watermarking is a technique to put some message behind the cover medium in such a manner so as to extract the same at the receiver end if and only if the receiver have appropriate material with it. The aim and objective of the digital watermarking is to use this technique effectively for copyright protection and proof of authentication. Watermarking is compiled with the requirements of robustness, payload capacity and perceptibility. Watermarking can be done in transform and spatial domain with good results in the transform domain. Considering the same this work makes use of DWT and SVD based video watermarking technique. In the DWT based method the frame first undergoes a sub band coding and then horizontal sub band is modified according to the message. One linear algebra method, namely singular value decomposition is also used for the purpose of embedding both binary and gray scale watermarks. Here the singular values of the frame of video are modified according to the message. For the evaluation of perceptibility at the transmitter side, two pixel quality matrices are calculated in each of the above mentioned methods, namely peak signal to noise ratio and mean square error.**

Keywords-digital watermarking; singular value dicompositiom; disceret wavelate transform; peak signal to noise ratio; mean square error; perceptibility

I. INTRODUCTION

Today majority of the data transfer over the internet is in the form of the video and image and that is why there is a question of copyright protection and the proof of ownership comes into the picture every now and then. Both the task can be completed by a concept called digital watermarking which includes a number of techniques that are used to imperceptibly convey information by embedding it into the cover data [1]. In our paper we have taken video sequence as our cover data watermarking is thus called the Video Watermarking. The major factors that increases the demands of the Video watermarking [1, 2] are stated as below.

- Privacy of the digital data is required and because the copying of a video is comparatively very easy.
- Fighting against the ―Intellectual property rights breach‖
- Tempering of the digital video must be concealed.
- Copyright protection must not be eroded.

In this paper we made use of the Discrete Wavelet Transform and mathematical linear algebra rule called singular value decomposition. In This paper shows the general idea of implementation of the embedding and extracting process of both the Methods for a video watermarking system and also comparison of both the methods.

II. DISCRETE WAVELET TRANSFORM

The transform of a signal is just another form of representing the signal. It does not change the information content present in the signal. The Wavelet Transform provides a time-frequency representation of the signal. A wave is an oscillating function of time or space and is periodic. In contrast, wavelets are localized waves. They have their energy concentrated in time or space and are suited to analysis of transient signals. The Wavelet Transform uses wavelets of finite energy [10].

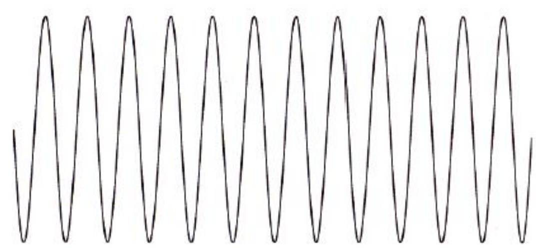

Figure 1. Demonstration of a Wave

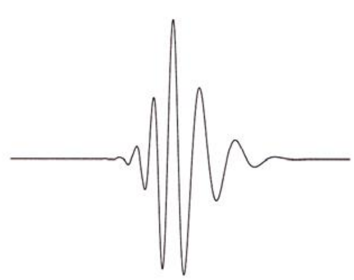

Figure 2. Demonstration of a Wavelet

To understand the basic idea of the DWT let us focus on one dimensional signal. The signal is passed through a low pass filter and a high pass filter so as to get both high and low frequency parts of the signal. High frequency part contains edge components wherein low frequency part contains information components. The same process is repeated for the low frequency part so as to get second level low and high frequency components. This process is continued until the signal has been entirely decomposed or stopped before by the application at hand. For compression and watermarking applications, generally no more than five decomposition steps are computed. Furthermore, from the DWT coefficients, the original signal can be reconstructed. The reconstruction process (synthesis) is called the inverse DWT (IDWT).

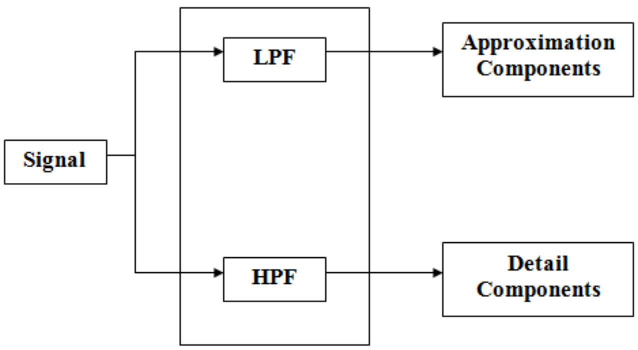

Figure 3. Filtering or decomposition process at basic level

Any signal contains its most important and informative part in its low-frequency component and that is the reason why low frequency components are very important. The high-frequency content, on the other hand, imparts flavour or nuance. Consider the human voice. If high frequency components are removed from a song it would sound different, but one can still identify the saying. However, if low-frequency components are removed, one would be able to hear garbage only.

In wavelet analysis two words are frequent i.e. approximations and details. The approximations are the high-scale, low-frequency components of the signal. The details are the low-scale, high-frequency components. The first stage of the decomposition wherein signal is applied to low pass and high pass filters. If the original signal is of size 1x1000 then size of each of the approximation and detail component would be 1x1000. So the output contains twice the samples compare to input. So output of both of the filter is down sampled by 2 so that each of the output would have half the size of the original signal and hence the total size equals to that of the original signal. Figure shows the concept. The decomposition or analysis process with down sampling produces DWT coefficients.

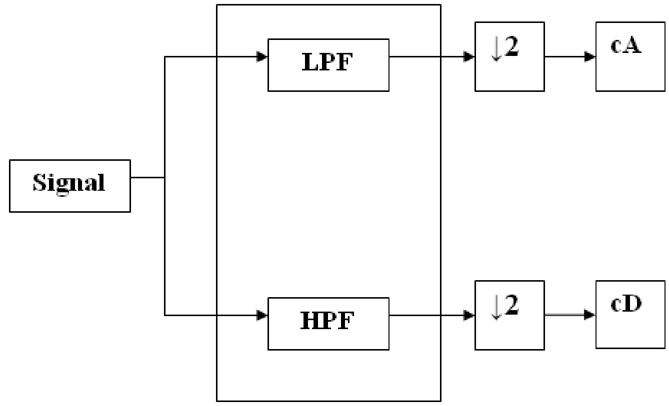

Figure 4. Analysis with down sampling

The DWT and IDWT for a two dimensional image k(m,n) can be similarly defined by implementing the one dimensional DWT and IDWT for each dimension m and n separately, resulting in the pyramidal representation of an image. This kind of two-dimensional DWT leads to a decomposition of approximation coefficients at level j in four components: the approximation at level j +1, and the details in three orientations (horizontal, vertical, and diagonal).

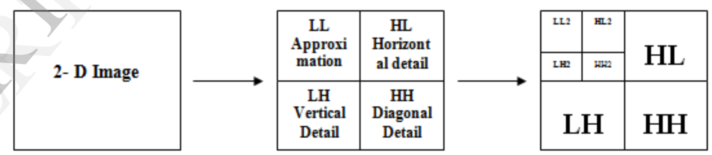

Figure 5. Basic decomposition steps for images

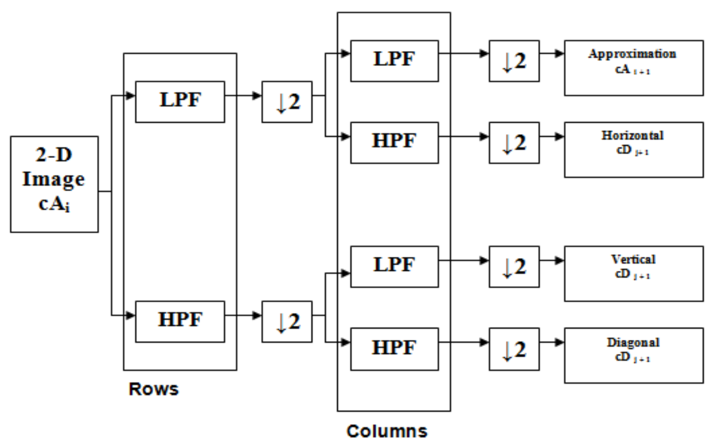

Figure .6 describes the basic decomposition steps for images

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A. *Embedding Process[3]*

Steps for embedding binary message behind the video using DWT as a main tool.

1. Original Video is broken into number of frames.
2. Two Random sequences are designed and named pn_sequence_h and pn_sequence_v.
3. Color space conversion is done from RGB to YCbCr.
4. Discrete wavelet transform is applied to Y frame and HL and LH component is chosen for the embedding purpose.
5. Add PN Sequence to HL and LH cpmponents if Wtermarked bit is 0
    a. cH=cH+alpha*pn_sequences_h; cV=cV+alpha*pn_sequence_v;
6. Inverse DWT is applied to get watermarked Y frame.
7. Inverse color-space conversion is applied so as to get modified RGB frame.
8. Steps 3 to 7 are executed for the next frame and the process continues until the last frame.
9. Watermarked Video is obtained by combining all watermarked frames.

B. *Extraction Process[3]*

Steps for extracting binary message at the receiver end from video.

1. Watermarked Video is broken into number of frames.
2. Two Random sequences are designed and named pn_sequence_h and pn_sequence_v. These sequences must be same as that at the embedding side.
3. Color space conversion is done from RGB to YCbCr.
4. Discrete wavelet transform is applied to Y frame .
5. Initialize watermark vectors to all ones.
6. Find correlation of HL with pn_sequences_h and LH with pn_sequences_v components of watermarked image.If correlation is found than message bit is assigned 0, otherwise it is assigned 1 and watermark is extracted
7. Steps 3 to 6 are executed for the next frame and the process continues until the last frame.

C. *Result*

Figure 7. First five frames from original video

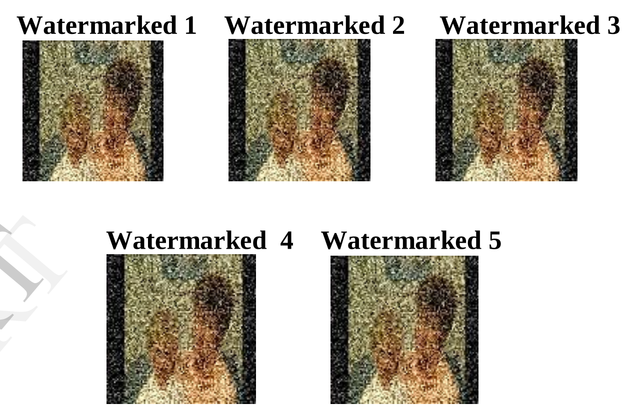

Figure 8. Watermarked first five frames of DWT

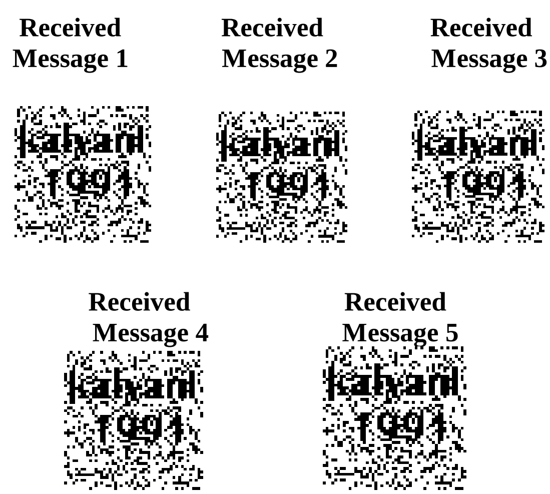

Figure 9. Received message for DWT

Table 1: Visual Quality Matrices Value for DWT with alpha=10

Frame No	PSNR	MSE	CORRELATION
1	14.4092	2.3559e+03	0.5354
2	14.4107	2.3551e+03	0.5340
3	14.4089	2.3561e+03	0.5345
4	14.4095	2.3558e+03	0.5345
5	14.4121	2.3544e+03	0.5340

III. SINGULAR VALUE DECOMPOSITION

Singular value decomposition (SVD) is a numerical technique based on the linear algebra
The singular value decomposition of a rectangular matrix A is decomposed in the form
$A=USV^T$

Where A is an matrix. m×n . U, V are the orthogonal matrices. D is a diagonal matrix comprised of singular value of A. The singular values $\sigma_1 \geq \sigma_2 \ldots \sigma_n \geq 0$ appears in the descending order along with the main diagonal of S. The singular values are obtained by taking the square root of Eigen value of AA^T and A^TA.

Above Equation can be written as
$\mathbf{A=USV^T}$

$$A = [U_1, U_2, U_3, \ldots \ldots . U_n] \begin{bmatrix} \sigma_1 & 0 & 0 \\ 0 & \sigma_2 & 0 \\ 0 & \ldots & \sigma_n \end{bmatrix} \begin{bmatrix} V_1^T \\ \vdots \\ V_n^T \end{bmatrix}$$

The relation between SVD and Eigen values are given below.

$$\mathbf{A=USV^T}$$

Now

$$\mathbf{AA^T = USV^T(USV^T)^T = USV^T\ VSU^T = US^2U^T}$$

Also

$$\mathbf{A^TA = (USV^T)^T\ USV^T = VSU^T\ \ USV^T = VS^2V^T}$$

Thus U and V are calculated as a Eigen vector of $\mathbf{AA^T}$ and $\mathbf{A^TA}$ respectively. The square root of Eigen values are the singular values along the diagonal of matrix S. If the matrix A is real then the singular values are always real number and U and V are also real [9].

It is used to diagonalize matrices in numerical analysis. It is an algorithm developed for a variety of applications. When weApply SVD to an Image A of size MxN, we find three matrices, namely U, V and S whose properties are:

- We can represent A = USVT.
- U and V matrices are called Unitary matrices having size MxM and NxN respectively.
- S matrix is called diagonal matrix having size MxN.
- The columns of the U matrix are called the left singular vectors while the columns of the V matrix are called theright singular vectors of A.
- The diagonal entries of S are called the singular values of A and are arranged in decreasing order.
- The singular values (SVs) of an image have very good stability, i.e., when a small perturbation is added to an image, its SVs do not change significantly.

A. Embedding Process[6]

Steps for embedding binary message behind the video using SVD as a main tool.

1. Original Video is broken into number of frames.
2. A frame is taken and Colorspace conversion is applied to convert RGB frame into YCbCr frame.
3. Y frame is selected for the embedding purpose.
4. SVD is applied on the selected Y frame.
5. Watermark is rescaled to the size of the Singular Component i.e. S
6. Singular component is modified as D = S + alpha* W where W is the watermark and alpha is the gain factor.
7. Again SVD is applied on the modified Singular Component.
8. Selected sub-band is modified as New_Value = U*Modified_S*VT
9. Inverse colorspace conversion is applied.
10. Steps 2 to 9 are executed until the end of all frames.
11. All watermarked frames are combined to have watermarked video.

B. Extraction Process[6]

Steps for extracting binary message at the receiver end from video.

1. Watermarked Video is broken into number of frames.
2. A frame is taken and Colorspace conversion is applied to convert RGB frame into YCbCr frame.
3. Y frame is selected for the extracting purpose.
4. SVD is applied on the selected Y frame.
5. Singular part is resized to have the size same as the message so as to have D = U*S*VT
6. Watermark is generated by applying (D - S) / alpha
7. The process is repeated for every frame and all watermarks are retrieved.

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C. Result

Figure 10. First five frames from original video

Figure 11. Watermarked first five frames of SVD

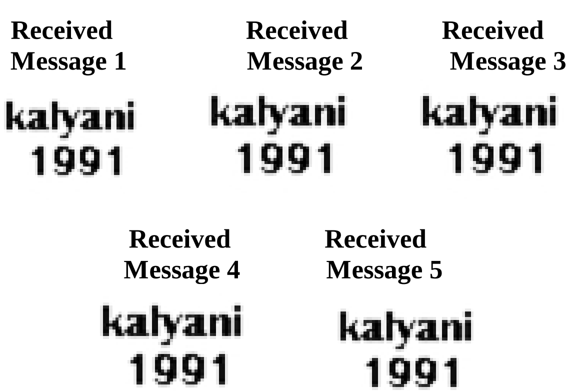

Figure 12. Received message for SVD

Table 2: Visual Quality Matrices Value for SVD with alpha=10

Frame No	PSNR	MSE	CORRELATION
1	37.0605	12.7946	0.9870
2	37.0765	12.7478	0.9870
3	37.0599	12.7965	0.9870
4	37.0362	12.8664	0.9870
5	37.0511	12.8224	0.9870

IV. COMPARISION

Table 3: Comparison of DWT and SVD

Frame No	PSNR		MSE		CORRELATION	
	DWT	SVD	DWT	SVD	DWT	SVD
1	14.4092	37.0605	2.3559e+03	12.7946	0.5354	0.987
2	14.4107	37.0765	2.3551e+03	12.7478	0.5340	0.987
3	14.4089	37.0599	2.3561e+03	12.7965	0.5345	0.987
4	14.4095	37.0362	2.3558e+03	12.8664	0.5345	0.987
5	14.4121	37.0511	2.3544e+03	12.8224	0.5340	0.987

V. CONCLUSION

DWT technique consume less time for embedding message with compare to SVD technique but the received message in SVD is better then DWT. The watermarked video Quality in SVD is also better then DWT.

VI. FUTURE WORK

In Future , The two method namely, Discrete Wavelet Transform and Singular Value Decomposition will combine in such a manner that the visual quality remains good after embedding the message and also consume less time for embedding Message so that result will be better.

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