International Journal of Computer Applications (0975 – 8887)
Volume 71– No.13, May 2013

A Method for Watermarking in Digital Videos by using Hybrid Transforms and Edge Detection

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ABSTRACT

An approach for three robust and semi-blind digital video watermarking algorithms has been proposed in this paper. These algorithms are based on hybrid transforms using the combination of Discrete Cosine Transform and Singular Value Decomposition (DCT- SVD), Discrete Wavelet Transform and Singular Value Decomposition (DWT-SVD) and Discrete Wavelet Transform, Discrete Cosine Transform and Singular Value Decomposition (DWT-DCT-SVD). The original video is divided to number of frames. On one frame, the three hybrid transform algorithms have been applied separately. The process is repeated for all the reaming frames. The performance of the proposed algorithms is evaluated with respect to imperceptibility and robustness. The results show that the proposed algorithms give a good Peak Signal to Noise Ratio (PSNR), however their performance varied with respect to robustness.

Keywords

Watermarking, DWT, DCT, SVD, Robustness, and Hybrid transforms, Edge Detection

1. INTRODUCTION

Due to the rapid and extensive growth of network technology, digital information can now be distributed much faster and easier. It causes the condition of illegal copies and spread of copyright reserved information. So, to protect the copyright of multimedia information and to decrease the impulse to copy and spread copy right reserved multimedia information, there are immense technical challenges in discouraging unauthorized copying and distributing of digital information. Fortunately, digital watermarking has been proposed as a method to embed an invisible signal into multimedia data so as to attest the owner identification of the data and discourage the unauthorized copying and distributing of digital information. In digital image watermarking the inserted watermark should not degrade the visual perception of an original image. This information of digital data can be extracted later for ownership verification [1]. Digital watermarking can applied to a variety of fields like text, image, audio, video and software. A lot of techniques are available for protecting the copyrighted material. The first method for hiding watermarking is by directly changing original cover-media. The advantages are simple and fast calculated but cannot protect itself from varied signal processing attacking [2, 3]. The most of watermarking techniques embed the information data in the coefficients of transformation domain of the cover image, such as Fourier transformation, discrete cosine transformation, wavelet transformation and singular value decomposition etc. Image watermarking algorithms using Discrete Cosine Transform (DCT) [4], the data hiding capacity is high in spatial domain and frequency domain algorithms based on DCT, SVD. However, these algorithms are hardly robust against various attacks, prone to tamper and degrade the quality of the watermarked image. Hybrid domain transforms are also available in the literature DCT- SVD [5, 6, 7] and DWT-SVD [8-12]. Now a day's people are looking to authenticate their video content by using either individual transforms or hybrid transforms [13 - 22] also.

In this paper, three semi-blind reference video watermarking algorithms DCT-SVD, DWT-SVD and DWT-DCT-SVD have been proposed. The rest of the paper is organized as follows: section 2 contains our proposed algorithms, while Section 3 provides experimental results and in section 4 conclusions and in Section 5 references.

2. PROPOSED ALGORITHMS

The watermark embedding and extraction process has shown in figure 1.

2.1 Algorithm using DCT-SVD

2.1.1. Watermark Embedding Procedure

The objective of this procedure is to embed the watermark into the cover or host video without degrading the original host video.

Step 1: Divide the video scene into frames F_i, i = 1, 2, 3…………n.

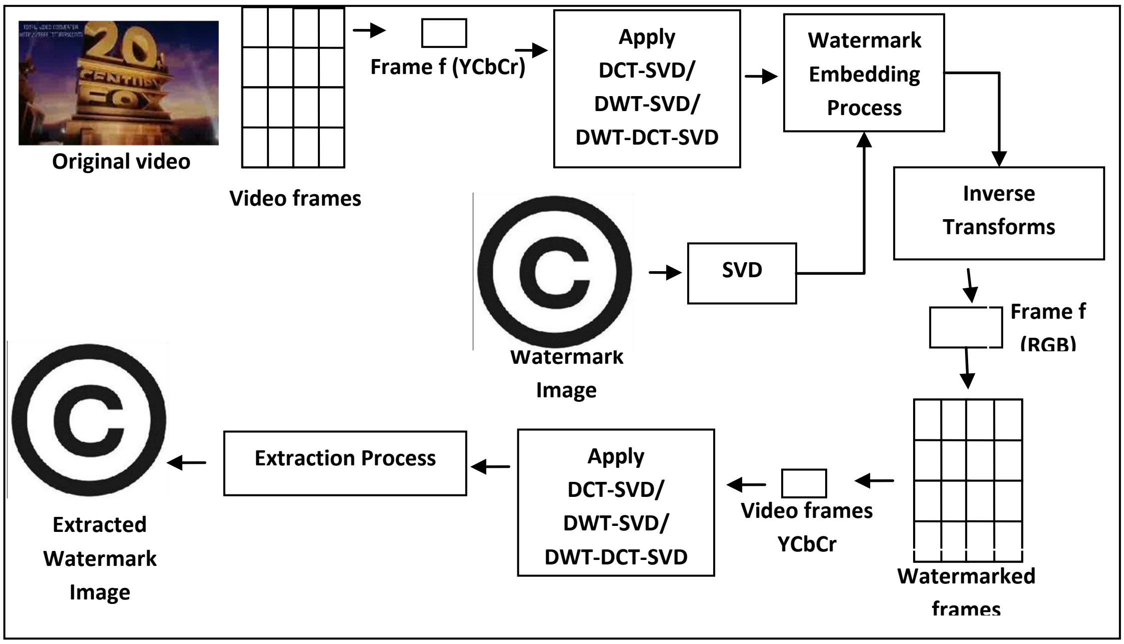
Step 2: Convert every video frame F_i from RGB to YC_bC_r color matrix format.

Step 3: Compute the steps 4 to 13 on the Y matrix in each frame F_i.

Step 4: The Y matrix is segmented into blocks of size $p_1 \times p_2$ via ZIG_ZAG sequence denoted by F^l, where l is the number of blocks.

Step5: Find out the number of edges in each block.

Step6: The numbers of edges in each block are stored in descending order. Then make a threshold on the number of edges in each block. Those blocks, which have number of edges greater than or equal to threshold, are considered as significant blocks and are used for making reference image, F_{ref} which is a size of n × n.



Step7: Perform DCT on the reference image, which is denoted by f_{DCT}

Step8: Perform SVD onf_{DCT}, which is denoted by

$$f_{DCT}^{SVD} = U_{DCT} * S_{DCT} * V_{DCT}^T \qquad (1)$$

Step9: Perform SVD transform on watermark image W, which is denoted by

$$f_W^{SVD} = U_W * S_W * V_W^T \qquad (2)$$

Step10: Modify the singular values of reference image with the singular values of watermark as

$$(S_{ref})^* = S_{DCT} + \beta * S_w \qquad (3)$$

Where, β gives the watermark depth.

Step11: Perform inverse SVD,

$$f_{isvd}^* = U_{DCT} * S_{ref}^* * V_{DCT}^T \qquad (4)$$

Step12: Perform inverse DCT to construct the modified reference image, denoted byf_{ref}^*. Again f_{ref}^* is segmented into blocks of size $p_1 \times p_2$ and mapped onto their original positions for constructing the watermarked image.

Step 13: Convert the video frames from YC_bC_r to RGB color matrix.

Step 14: Reconstruct frames into final watermarked video scene F_i^*

2.1.2. Watermark extraction procedure

Watermark extraction procedure as follows:

Step 1: Divide the watermarked video scene into framesF_i^*, i = 1, 2, 3…………n.

Step 2: Convert every watermarked video frame F_i^* from RGB to YC_bC_r color matrix format.

Step 3: Compute the steps 4 to 8 for the Y matrix in each frame F_i^*.

Step 4: Using the positions of significant blocks, make the reference image from the watermarked Y matrix,

Step 5: Perform DCT on both F_{ref}^W and original reference image, which is denoted by f_{ref}^W and f_{ref}.

Step 6: Perform SVD transform on both f_{ref} and f_{ref}^W.

$$f_{ref} = U_{f_{ref}} * S_{f_{ref}} * V_{f_{ref}}^T \qquad (5)$$

$$f_{ref}^W = U_{f_{ref}^W} * S_{f_{ref}^W} * V_{f_{ref}^W}^T \qquad (6)$$

Step 7: Extract the singular values of the watermark.

$$\sigma_W^{ext} = \frac{\sigma_{f_{ref}^W} - \sigma_{f_{ref}}}{\beta} \qquad (7)$$

Step 8: Obtain the extracted watermark as:

$$W^{ext} = U_W * S_W^{ext} * V_W^T \qquad (8)$$

Step 9: Construct the watermark image W by cascading watermarks from all frames.

2.2 Algorithm using DWT-SVD

2.2.1. Watermark Embedding Procedure

Step 1: Divide the video scene into framesF_i, i = 1, 2, 3…………n.

Step 2: Convert every video frame F_i from RGB to YC_bC_r color matrix format.

Step 3: Compute the steps 4 to 13 on the Y matrix in each frameF_i.

Step 4: The Y matrix is segmented into blocks of size $p_1 \times p_2$ via ZIG_ZAG sequence denoted by F^l, where l is the number of blocks.

Step5: Find out the number of edges in each block.

Step6: The numbers of edges in each block are stored in descending order. Then make a threshold on the number of edges in each block. Those blocks, which have number of edges greater than or equal to threshold, are considered as significant blocks and are used for making reference image, F_{ref} which is a size of n × n.

Step 7: Perform DWT on the reference image. It divides the image into four sub bands, LL, LH, HL and HH. Select the LL band , Which is denoted by $f_{LL?}$

Step 8: Perform SVD transform on both f_{ref} and watermark image.

$$f_{LL} = U_{LL} * S_{LL} * V_{LL}^T \qquad (9)$$

$$W = U_W * S_W * V_W^T \qquad (10)$$

Step 9: Modify the single values of reference image with the singular values of watermark as

$$\left(\sigma_{f_{ref}}\right)^* = \sigma_{LL} + \beta * \sigma_W \qquad (11)$$

Here β give's the watermark strength.

Step 10: Perform inverse SVD,

$$f_{ref}^* = U_{f_{ref}} * S_{f_{ref}}^* * V_{f_{ref}}^T \qquad (12)$$

Step 11: Perform inverse DWT to construct the modified reference image, denoted by f_{ref}^*. Again f_{ref}^* is segmented into blocks of size $p_1 \times p_2$ and mapped onto their original positions for constructing the watermarked image.

Step 12: Convert the video frames from YC_bC_r to RGB color matrix.

Step 13: Reconstruct frames into final watermarked video scene F_i^*

2.2.2. Watermark Extraction Procedure

Step 1: Divide the watermarked video scene into frames F_i^*, i = 1, 2, 3…………n.

Step 2: Convert every watermarked video frame F_i^* from RGB to YC_bC_r color matrix format.

Step 3: Compute the steps 4 to 8 for the Y matrix in each frame F_i^*.

Step 4: Using the positions of significant blocks, make the reference image from the watermarked Y matrix,

Step 5: Perform DWT on both F_{ref}^W and original reference image, which is denoted by f_{ref}^W and f_{LL}.

Step 6: Perform SVD transform on both f_{LL} and f_{ref}^W.

$$f_{LL} = U_{LL} * S_{LL} * V_{LL}^T \qquad (13)$$

$$f_{ref}^W = U_{f_{ref}^W} * S_{f_{ref}^W} * V_{f_{ref}^W}^T \qquad (14)$$

Step 7: Extract the singular values of the watermark.

$$\sigma_W^{ext} = \frac{\sigma_{f_{ref}^W} - \sigma_{f_{LL}}}{\beta} \qquad (15)$$

Step 8: Obtain the extracted watermark as:

$$W^{ext} = U_W * S_W^{ext} * V_W^T \qquad (16)$$

Step 9: Construct the image watermark W by cascading watermarks from all frames.

2.3. Algorithm using DWT-DCT-SVD

2.3.1. Watermark Embedding Procedure

Step 1: Divide the video scene into frames F_i, i = 1, 2, 3…………n.

Step 2: Convert every video frame F_i from RGB to YC_bC_r color matrix format.

Step 3: Compute the steps 4 to 11 for the Y matrix in each frame F_i.

Step 4: The Y matrix is segmented into blocks of size $p_1 \times p_2$ via ZIG_ZAG sequence denoted by F^l, where l is the number of blocks.

Step5: Perform DWT on the reference image, which is denoted by f_{DWT}.

Step6: Perform DCT on the LH band of DWT decomposition, which is denoted by f_{DCT}.

Step7: Apply SVD to f_{DCT}.

$$f_{DCT}^{SVD} = U_{DCT}^{SVD} * S_{DCT}^{SVD} * V_{DCT}^{SVD^T} \qquad (17)$$

Step6: perform SVD on watermark image.

$$W_{SVD} = U_W * S_W * V_W^T \qquad (18)$$

Step7: Modify the singular values of reference image with the singular values of watermark as

$$f_{SVD}^* = S_{DCT}^{SVD} + \beta * S_W \qquad (19)$$

Where, β gives the watermark depth.

Step8: Perform inverse SVD,

$$f_{isvd}^* = U_{DCT}^{SVD} * f_{SV\,D}^* * V_{DCT}^{SVD^T} \qquad (20)$$

Step9: perform inverse DCT and inverse DWT to construct the modified reference image, denoted by f_{ref}^*. Again f_{ref}^* is segmented into blocks of size $p_1 \times p_2$ and mapped onto their original positions for constructing the watermarked image.

Step 12: Convert the video frames from YC_bC_r to RGB color matrix.

Step 13: Reconstruct frames into final watermarked video scene F_i^*

2.3.2. Watermark Extraction Procedure

Step 1: Divide the watermarked video scene into frames F_i^*, i = 1, 2, 3…………n.

Step 2: Convert every watermarked video frame F_i^* from RGB to YC_bC_r color matrix format.

Step 3: Compute the steps 4 to 8 for the Y matrix in each frame F_i^*.

Step 4: Using the positions of significant blocks, make the reference image from the watermarked Y matrix,

Step2: Perform DWT and DCT on watermarked image, F_{ref}^W.Which is denoted by f_{ref}^W.

Step3: Perform SVD transform on f_{ref}^W.

$$f_{ref}^W = U_{ref}^W * S_{ref}^W * V_{ref}^{W^T} \qquad (21)$$

Step4: Extract the singular values of the watermark.

$$S^{ext} = \frac{S_{ref}^W - S_{DCT}^{SVD}}{\beta} \qquad (22)$$

Step5: Obtain the extracted watermark as:

$$W^{ext} = U_w * S^{ext} * V_W^T \qquad (23)$$

3. RESULT ANALYSIS

The performance of proposed video watermarking algorithms is tested with host video clip of size 240 x360. The video clip is divided into number of frames. The watermark used in this experiment is a gray scale image. Snapshot from the video and the watermark are shown in Figure 2 and Figure 3 respectively.

Fig 2: cover video snapshot

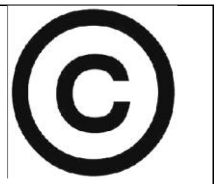


Fig 3: Watermark

Fig 4: watermarked video snapshot

Fig 5: Extracted watermark

The corresponding watermarked video snapshot and the extracted watermark has been shown in figure 4 and figure 5 respectively.

3.1. Performance Metrics

Imperceptibility means that the perceived quality of the image should not be distorted by the presence of the watermark. The peak signal to noise ratio (PSNR) is typically used to measure the degradation between original image and watermarked image.

$$RMSE = \sqrt{\frac{[f(i,j) - F(i,j)]^2}{N^2}} \qquad (24)$$

$$PSNR = 20\log\frac{255}{RMSE}\ db \qquad (25)$$

RMS is the Root Mean Square Error and is a comparison between the host image and watermarked image. f (i, j) and F(i, j) represent host and watermarked images respectively can be calculated by the equation 24 .

Robustness of a watermarking algorithm is that the embedded data should survive any signal processing operation. The similarity between the original watermark and the extracted watermark from the attacked watermarked image was measured by using the correlation factor ρ, which is computed using the following Equation 26.

$$\rho(w,\widetilde{w}) = \frac{\sum_{i=1}^{N} w_i \widetilde{w}_i}{\sqrt{\sum_{i=1}^{N} w_i^2}\ \sqrt{\sum_{i=1}^{N} \widetilde{w}_i^2}} \qquad (26)$$

Where N is the number of pixels in watermark, w and $\widetilde{w}$ is the original and extracted watermarks respectively. The correlation factorρ, may take values between -1and 1.

The robustness of the proposed algorithms is tested against the following video attacks: JPEG compression, video frame rotation, noise attacks (Gaussian and salt & pepper), cropping, resize, histogram equalization, motion blur, average, median filtering with mask values of 13 x 13, frame dropping, frame swapping and frame averaging.

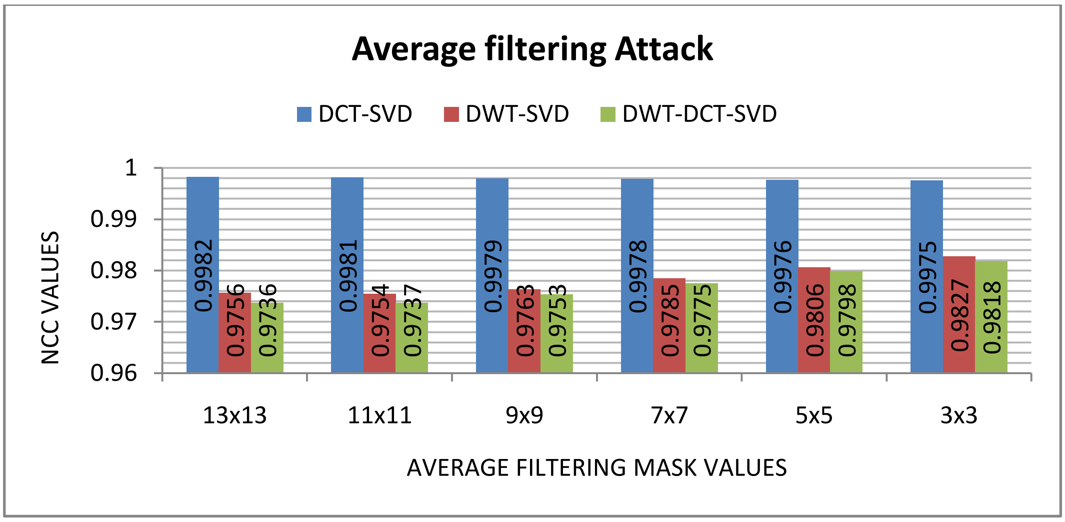


Fig 6: results for average filtering attack

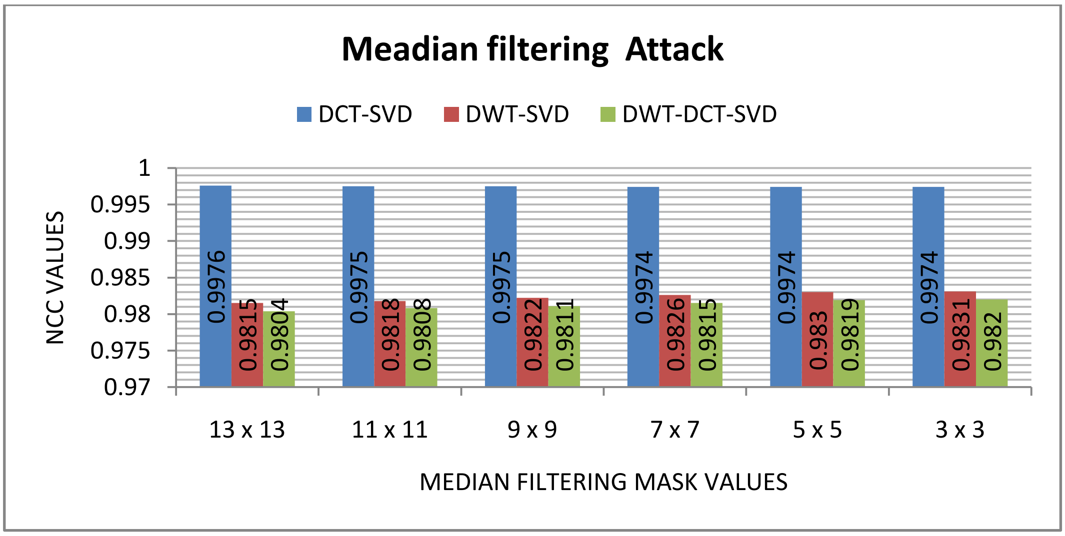


Fig 7: results for median filtering attack

Important attacks on video are average filtering and median filtering. This has sown in Figure 6 and figure 7 respectively. Two kinds of common attacks are Additive Gaussian Noise and the Salt & pepper Noise. Each noise is tested separately with the watermarked video frames. This is shown in Figure 8 and Figure 9 respectively. These results generally indicate robustness of the proposed algorithms against addition of Gaussian and Salt and Pepper noise.

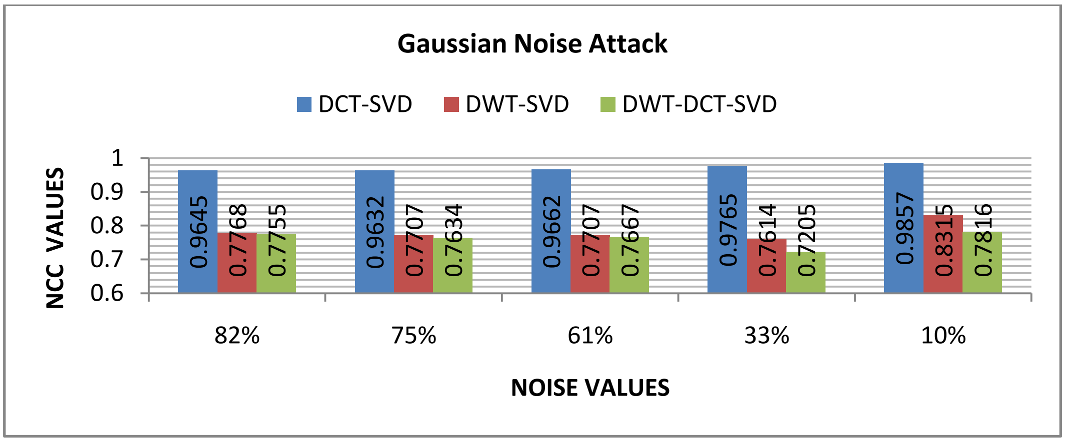


Fig 8: results for Gaussian noise attack

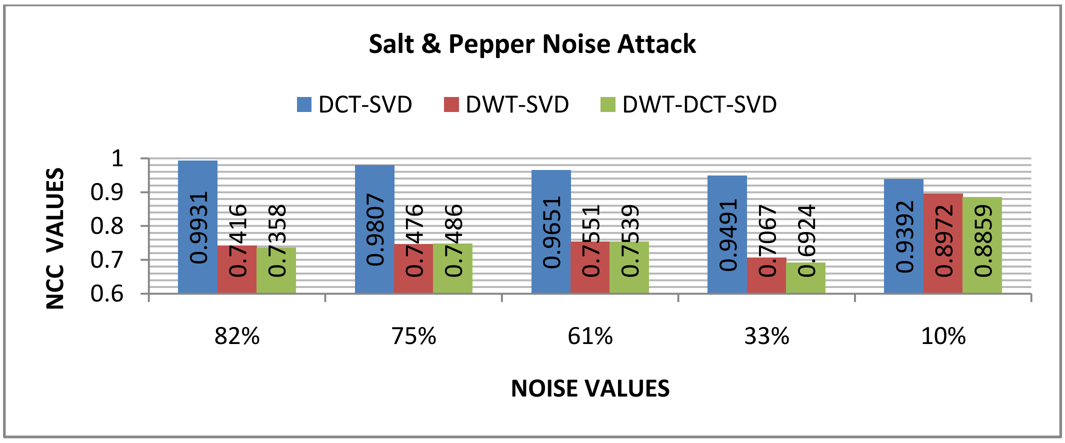


Fig 9: results for salt pepper noise attack

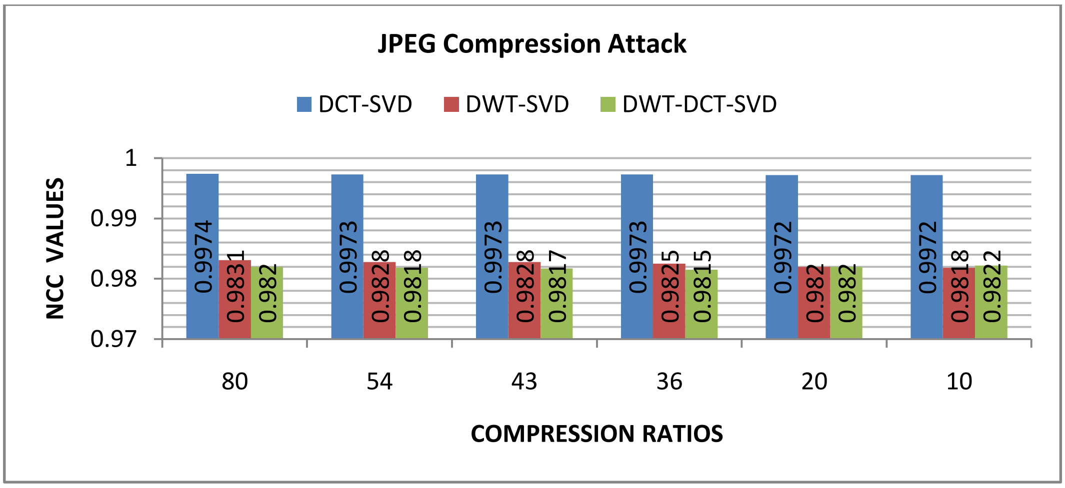


Fig 10: results for jpeg compression attack

The watermarked video frames are compressed with various quality factors. This is shown in Figure 10 and the correlation values indicate clearly the high robustness of the proposed algorithms. The watermarked video frames are rotated with different angles and is shown in Figure 11.

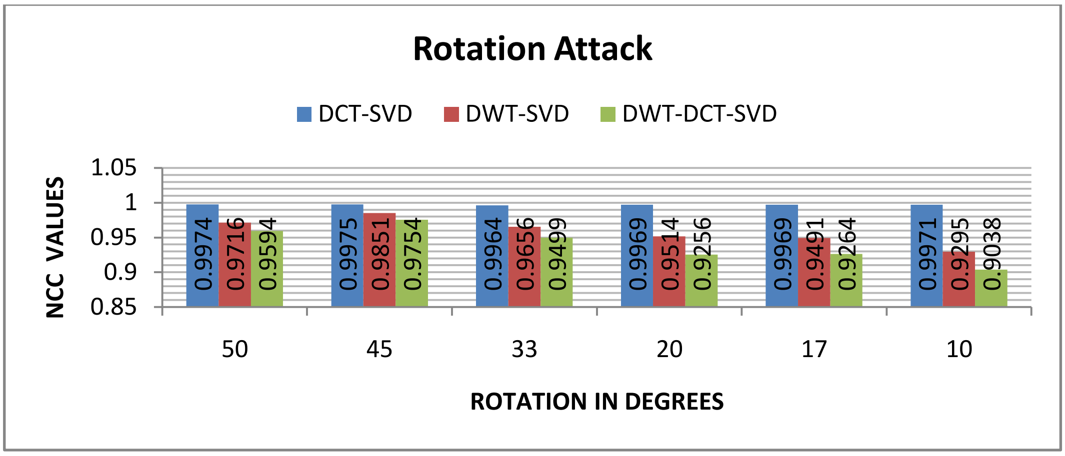


Fig 11: results for jpeg compression attack

Another important attack is cropping. Here, the video is cropped such that 25% area is reaming. The other prime image processing attack is resizing. The resizing is performed from 512-> 128-> 512. The results for cropping, resizing, Histogram equalization and sharpening attacks are shown in Figure 12. It is showed that the proposed algorithms have high robustness against these attacks. The results for motion blur, dropping swapping and averaging attacks are shown in Figure 13.

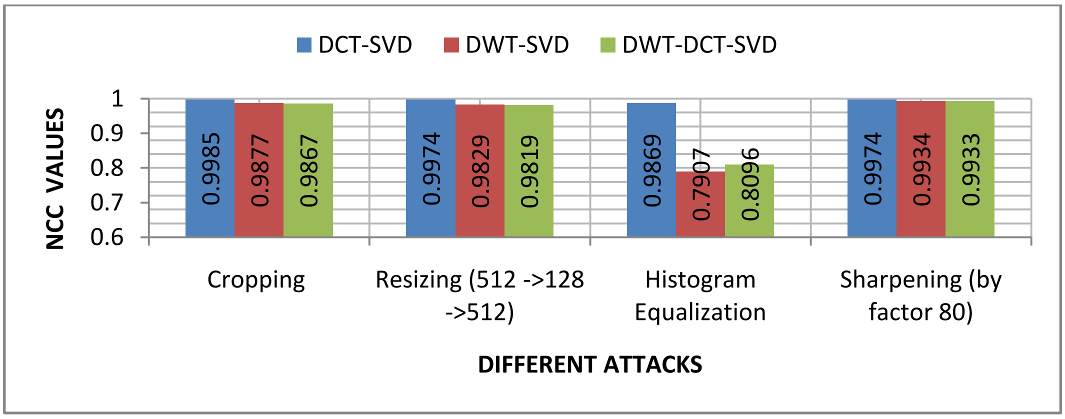


Fig 12: results cropping, resizing, Histogram equalization and sharpening attacks

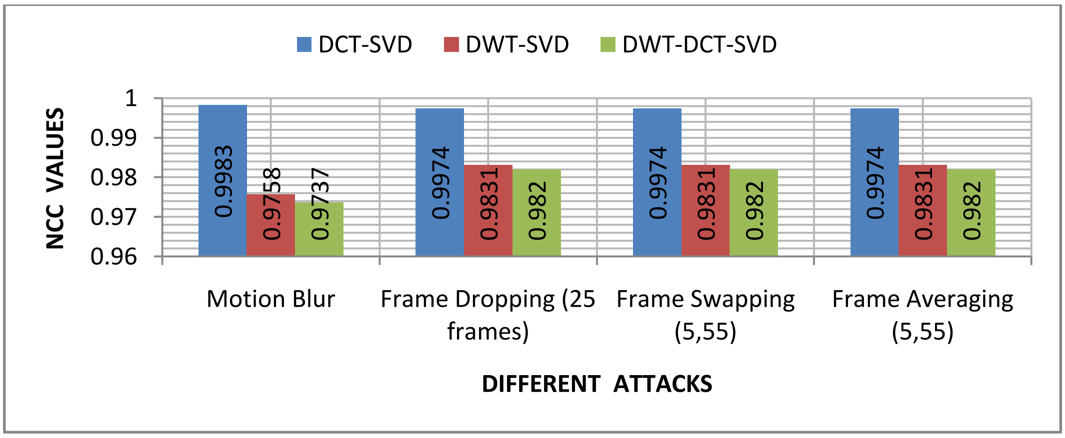


Fig 13: results motion blur, dropping swapping and averaging attacks

Table 1 : comparison of NCC values with existing algorithm

ATTACKS	Ref 22			Proposed Hybrid Methods		
	DCT-SVD	DWT-SVD	DWT-DCT-SVD	DCT-SVD	DWT-SVD	DWT-DCT-SVD
Average Filtering (13 x 13)	-0.1371	-0.1681	-0.1020	**0.9982**	**0.9756**	0.9736
Median Filtering (13 x 13)	0.0570	0.2067	0.2102	**0.9975**	0.9740	**0.9804**
Additive Gaussian noise (75%)	0.5850	0.7495	0.7178	**0.9638**	0.7707	**0.7755**
JPEG compression (80:1)	0.8973	0.9691	0.9668	**0.9820**	0.9749	**0.9820**
Rotation (50^0)	0.3958	-0.3049	0.4129	**0.9974**	0.9550	**0.9594**
Cropping (25% area remaining)	0.8921	0.7040	0.9179	**0.9985**	**0.9877**	0.9867
Resizing (512 -> 128 -> 512)	0.5036	0.6293	0.7391	**0.9974**	**0.9829**	0.9819
Histogram equalization	0.9617	0.9457	0.9724	**0.9869**	0.7907	**0.8096**
Sharpening (by factor 80)	----	----	----	**0.9974**	**0.9934**	0.9933
Motion blur	0.0319	-0.1819	0.1199	**0.9983**	**0.9758**	0.9737
Frame dropping(1-10 frames)	----	----	----	**0.9974**	**0.9831**	0.9820
Salt pepper(0.1)	0.3616	0.5655	0.5469	**0.9932**	0.8800	**0.8859**
Frame Swapping(5,50)	----	----	----	**0.9974**	**0.9831**	0.9820
Frame averaging (5,50)	----	----	----	**0.9974**	**0.9831**	0.9820

Table 2 : comparison of NCC values with existing algorithms

ATTACKS	Existing SVD Ref 13	Existing DWT-SVD Ref 19	Proposed DWT-SVD
JPEG compression (85)	0.9500	0.9780	**0.9831**
JPEG compression (45)	0.9345	0.9566	**0.9830**
JPEG compression (25))	0.9279	0.9520	**0.9826**
Rotation (5^0)	0.9620	0.9140	**0.9809**
Rotation (20^0)	0.9631	0.9501	**0.9722**
Rotation (45^0)	0.9645	0.9690	**0.9851**
Gaussian noise	**0.9212**	0.6847	0.8292
Gaussian noise	**0.9414**	0.6809	0.7331
Gaussian noise	**0.9500**	0.6766	0.7476
Salt pepper(0.1)	**0.9231**	0.6684	0.9018
Salt pepper(0.2)	**0..9343**	0.6770	0.8256
Salt pepper(0.33)	**0.9400**	0.6790	0.7016
Frame dropping	0.9760	0.8801	**0.9831**
Frame Swapping	1.0000	0.9030	**0.9831**
Frame averaging	1.0000	0.9011	**0.9831**

Table 3 : comparison of NCC values with existing algorithm DCT

ATTACKS	Existing DCT Ref 18	Proposed DCT-SVD
Salt pepper(0.001)	0.9700	**0.9982**
Gaussian noise (0.001)	0.9720	**0.9935**
Frame dropping(1-10 frames)	0.9700	**0.9974**
Frame averaging (5,50)	0.9700	**0.9974**
JPEG compression (80:1)	0.9000	**0.9913**
Gaussian filter	0.9800	**0.9974**
Resizing (512 -> 128 -> 512)	0.9270	**0.9974**

4. CONCLUSIONS

A new semi-blind reference video watermarking scheme based on hybrid transforms is presented in which the watermark is visually meaningful gray scale image instead of a noisy-type Gaussian sequence. For the extraction of watermark a reliable watermark extraction scheme is constructed. The hybrid transforms are DCT-SVD, DWT-SVD and DWT-DCT-SVD. Robustness of proposed methods is carried out by a variety of attacks. When the robustness values of three algorithms are compared, for all the attacks the DCT-SVD algorithm has given best robustness. The proposed algorithm results are compared with existing algorithms. In table 1, the proposed hybrid video algorithms are compared with ref 25 and the results for proposed algorithms are having best robustness. Further in table 2, the proposed algorithm DWT-SVD is compared with ref 16 and ref 22. When compared with ref 16, for noise attacks (Gaussian and Salt&pepper) the existing algorithm is best. When compared with ref 22, the proposed hybrid DWT-SVD algorithm has given best robustness for all the attacks. The proposed Hybrid DCT-SVD algorithm is also compared with ref 21 and the results are proved that the proposed algorithm is best.

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