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Video Watermarking Algorithms Using the Svd Transform

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Abstract:- Video watermarking is relatively a new technology that has been proposed to solve the problem of illegal manipulation and distribution of digital video. It is the process of embedding copyright information in video bit streams. In this paper, we propose two effective, robust and imperceptible video watermarking algorithms. The two algorithms are based on the algebraic transform of Singular Value Decomposition (SVD). In the first algorithm, watermark bit information are embedded in the SVD-transformed video in a diagonal-wise fashion, and in the second algorithm bits are embedded in a blocks-wise fashion. The performance of the two proposed algorithms was evaluated with respect to imperceptibility, robustness and data payload. Both algorithms showed similar but high level of imperceptibility, however their performance varied with respect to robustness and payload. The diagonal-wise based algorithm achieved better robustness results, while the block-wise algorithm gave higher data payload rate.

Keywords:- Digital Video Watermarking, Singular Value Decomposition (SVD), Robustness, Imperceptibility, Data Payload.

I. INTRODUCTION

Video watermarking is relatively a new technology that has been proposed to solve the problem of illegal manipulation and distribution of digital video. It is the process of embedding copyright information in video bit streams [1]. In this paper, we propose two effective, robust and imperceptible video watermarking algorithms. The two algorithms are based on the algebraic transform of **Singular Value Decomposition (SVD)**. In the first algorithm, watermark bit information are embedded in the SVD- transformed video in a diagonal-wise fashion, and in the second algorithm bits are embedded in a blocks-wise fashion. The performance of the two proposed algorithms was evaluated with respect to imperceptibility, robustness and data payload. Both algorithms showed similar but high level of imperceptibility, however their performance varied with respect to robustness and payload. The diagonal-wise based algorithm achieved better robustness results, while the block- wise algorithm gave higher data payload rate. The main aim of this paper is to hide the information in the video for the security purpose [3] [4]. Video watermarking is relatively a new technology that has been proposed to solve the problem of illegal manipulation and distribution of digital video. It is the process of embedding copyright information in video bit streams.

II. VIDEO

A recording of a motion picture or television program for playing through a television set.

A. Number of frames per second:

Frame rate, the number of still pictures per unit of time of video, ranges from six or eight frames per second (frame/s) for old mechanical cameras to 120 or more frames per second for new professional cameras. PAL (Europe, Asia, Australia, etc.) and SECAM (France, Russia, parts of Africa etc.) standards specify 25 frame/s, while NTSC (USA, Canada, Japan, etc.) specifies 29.97 frame/s. Film is shot at the slower frame rate of 24 photograms/s, which complicates slightly the process of transferring a cinematic motion picture to video. The minimum frame rate to achieve the illusion of a moving image is about fifteen frames per second.

B. Aspect ratio:

Aspect ratio describes the dimensions of video screens and video picture elements. All popular video formats are rectilinear, and so can be described by a ratio between width and height. The screen aspect ratio of a traditional television screen is 4:3, or about 1.33:1. High definition televisions use an aspect ratio of 16:9, or about 1.78:1. The aspect ratio of a full 35 mm film frame with soundtrack (also known as the Academy ratio) is 1.375:1.

C. Color space and bits per pixel:

Color model name describes the video color representation. YIQ was used in NTSC television. It corresponds closely to the YUV scheme used in NTSC and PAL television and the YDB Dr scheme used by SECAM television.

The number of distinct colors that can be represented by a pixel depends on the number of bits per pixel (bpp). A common way to reduce the number of bits per pixel in digital video is by Chroma (e.g. 4:4:4, 4:2:2, 4:2:0/4:1:1)

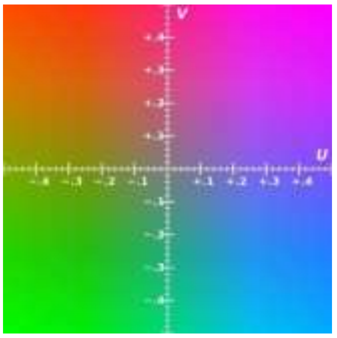

Fig.1. U-V color plane

D. Video Quality:

Video quality can be measured with formal metrics like PSNR or with subjective video quality using expert observation.

The subjective video quality of a video processing system may be evaluated as follows:

a. Choose the video sequences (the SRC) to use for testing.
b. Choose the settings of the system to evaluate (the HRC).
c. Choose a test method for how to present video sequences to experts and to collect their ratings.
d. Invite a sufficient number of experts, preferably not fewer than 15.
e. Carry out testing.
f. Calculate the average marks for each HRC based on the experts' ratings.

Many subjective video quality methods are described in the ITU-T recommendation BT.500. One of the standardized method is the Double Stimulus Impairment Scale (DSIS). In DSIS, each expert views an unimpaired reference video followed by an impaired version of the same video. The expert then rates the impaired video using a scale ranging from "impairments are imperceptible" to "impairments are very annoying".

III. WATERMARK

A. Watermark: As a Watermark you can use your site name, author name of a video (any text) or logotype (any graphic file, including animation). Watermark will been displayed during video or will be put over static image. **B. Watermark function:** Very often people share files between themselves. Watermarks are used to show that just you have author„s rights to a particular video or graphic file. One more function is placing contact data on your product, for instance, your web site URL. Watermark can be applied to every frame of a video. With our tools for making watermarks, you can create low-pressure semi-transparent, appearing in set time watermarks what won„t make your product worse. Video protection is a main, but not only field of use of watermarks. Using watermarking mechanism you can create built-in menu, add subtitles, apply simple video effects etc...

IV. VIDEO WATERMARKING

As digital video-based application technologies grow, such as Internet video, wireless video, videophones, and video conferencing, the problem of unauthorized copying and distribution of digital video rises more and more, thus creating copyright dilemma for the multimedia industry in general, and to the audio-video industry in particular. Many researches and technologies were proposed to provide methods to solve the problem of illegal copying and manipulations of digital video. An attractive method that has been proposed a decade ago to implement copyright information in multimedia documents is digital watermarking [7].

Digital watermarking refers to embedding watermarks in a multimedia documents and files in order to protect them from illegal copying and identifying manipulations. This promising technology received a considerable attention for embedding copyright information in a broad range of multimedia applications. In particular, video proposed watermarking techniques embed small copyright information, called a watermark, in the digital video such that the watermark is imperceptible and robust against attempts to degrade it or remove it from the digital object. Video watermarking research received less attention than image watermarking due to its inherit difficulty, however, many algorithms have already been proposed.

Video watermarking approaches can be classified into two main categories based on the method of hiding watermark information bits in the host video. The two categories are: Spatial domain watermarking, and transform-domain watermarking. In spatial-domain watermarking techniques, embedding and detection are performed on spatial pixels values (luminance, chrominance, and color space) or on the overall video frame. Spatial-domain techniques are easy to implement, however they are not robust against common digital signal processing operations such as video compression. Transform-domain techniques, on the other hand, alter spatial pixel values of the host video according to a pre-determined transform. Commonly used transforms are the Discrete Cosine Transform (DCT), the Fast Fourier Transform (FFT), the Discrete Wavelet Transform (DWT) [8], and the Singular Value Decomposition (SVD). Transform-domain watermarking techniques proved to be more robust and imperceptible compared to spatial domain techniques since disperse the watermark in the special domain of video frame, making it very difficult to remove the embedded watermark.
In this paper, we propose two blind, imperceptible and robust video watermarking algorithms based on Singular Value Decomposition (SVD). Each algorithm embeds the watermark in the transform-domain YCbCr space thus spreading the watermark in each frame of the video. The first algorithm suggests hiding watermark information in a diagonal-wise manner in one of three SVD matrices [19]; U, S and V. On the other hand, the second algorithm hides the watermark information in a block-wise manner in either the U or V matrices. The rest of the paper is organized as follows. The SVD transform [16]is outlined. The two proposed video SVD-based watermarking algorithms [17][18] are described. Performance evaluation of the two algorithms with respect to imperceptibly, robustness and payload are described.

V. SINGULAR VALUE DECOMPOSITION

Singular Value Decomposition (SVD) [14] is a numerical technique for diagonalzing matrices in which the transformed domain consists of basis states that is optimal in some sense. The SVD of an N x N matrix A is defined by the operation:

A = U S V T (1)

Where **U** and **V . R є N x N** are unitary, and **S . R є N x N** is a diagonal matrix. The diagonal entries of S are called the singular values of A and are assumed to be arranged in decreasing order $\sigma_i > \sigma_{i+1}$. The columns of the **U** matrix are called the left singular vectors while the columns of the **V** matrix are called the right singular vectors of A. Each singular value σ_i specifies the luminance of an image layer while the corresponding pair of singular vectors specifies the geometry of the image layer. In SVD-based watermarking, a frame image is treated as a matrix decomposed into the three matrices; **S**, **U** and **V T**, as shown in below equation.

VI. FIRST PROPOSED SVD-BASED VIDEO WATERMARKING ALGORITHM

$$SVD(A) = \begin{bmatrix} U_{1,1} & . & . & U_{1,n} \\ U_{2,1} & . & . & U_{2,n} \\ . & . & . & . \\ U_{n,1} & . & . & U_{n,n} \end{bmatrix} \begin{bmatrix} \sigma_{11} & 0 & 0 & 0 \\ 0 & \sigma_{22} & 0 & 0 \\ . & . & . & . \\ 0 & 0 & 0 & \sigma_{nn} \end{bmatrix} \begin{bmatrix} V_{1,1} & . & . & V_{1,n} \\ V_{2,1} & . & . & V_{2,n} \\ . & . & . & . \\ V_{n,1} & . & . & V_{n,n} \end{bmatrix}^T$$

The first algorithm is based on transforming the host video using the SVD operator and then embedding the watermark information in the S, U, or V matrices diagonal-wise. The proposed algorithm consists of two procedures, the first embeds the watermark into the original video clip, while the other extracts it form the watermarked version of the video clip. We embed only the foreground pixels in the watermark. **A. Watermark Embedding Procedure:**
The embedding procedure of the first algorithm, with its three
possible variations, is described in details in the following steps:
Step 1: Divide the video clip into video scenes **Vsi**.
Step 2: Process the frames of each video scene using SVD
described in steps 3 ~ 9 below.
Step 3: Convert every video frame **F** from RGB to YCBCR
color matrix format.
Step 4: Compute the SVD for the Y matrix in each frame **F**. This operation generates 3
Matrices (U,S,V) such as:
Step 1: Divide the watermarked Video clip V' into watermarked scenes **Vsi'**.
Step 2: Process the watermarked frames of each watermarked
video scene using SVD as described in steps 3 ~ 7.
Step 3: Convert the video frame F' from RGB color matrix to

YCBCR.
Step 4: Compute the SVD for the Y matrix in frame F'. , this operation generates 3 Matrices (U, S, V).
Step 5: Extraction is done in one of the three SVD matrices:
U, V, or S, as follows: Extraction from Matrix U:
WVsi (i) =7th **LSB (fix(x))** (6) Extraction from Matrix V:
WVsi (i) =7th **LSB (fix(x))** (7) Extraction from Matrix S:
WVsi (i) = 7th **LSB (fix(s i, i))** (8) **Step 6:** Construct the image watermark WVsi by cascading all watermark bits extracted from all frames.
Step 7: Repeat the same procedure for all video scenes.

VII. SECOND PROPOSED SVD-BASED VIDEO WATERMARKING ALGORITHM

The second algorithm is based on transforming the host video using the SVD operator and then embedding the watermark information in the U, or V matrices in a block-wise fashion. The proposed algorithm consists of two procedures, the first embeds the watermark into the original video clip, while the other extracts it form the watermarked version of the video clip. We embed only the foreground pixels in the watermark. **A. Watermark Embedding Procedure:**
The embedding procedure of the second algorithm, with its three possible variations, is described in details in the following steps:
Step 1: Divide the video clip into video scenes Vsi.
Step 2: Process the frames of each video scene using SVD described in steps 3 ~ 8 below.
Step 3: Convert every video frame F from RGB to YCBCR
Y= UY SY VY
(2)
color matrix format.
Step 5: Rescale the watermark image so that the size, of the watermark will match the size of the matrix which will be used for embedding either U, V or S.
Step 6: Embedding can be done in one of the three SVD
matrices: U, V, or S, as follows: Embedding in Matrix U Diagonal-wise:
T
Step 4: Compute the SVD for the Y matrix in each frame F. This operation generates 3Matrices (U, S, V).
Step 5: Rescale the watermark image so that the size, of the
watermark will match the size of the matrix which will be used for embedding U or V.
Embedding in Matrix U Block-wise:
Y'= UY' **S**Y **V**Y
Embedding in Matrix V Diagonal-wise:
(3)
Y'= **U**Y' **S**Y **V**Y$^{\mathbf{T}}$
Embedding in Matrix V Block-wise:
(9)
Y'= UY SY VY' T (4)
Y'= UY' SY VY T
(10)
Embedding in Matrix S Diagonal-wise:
Y'= UY SY' VY$^{\mathbf{T}}$
(5)
Where **Y'** is the updated luminance in the YCBCR color representation.

Step 7: Convert the video frames F' from YCBCR to RGB color matrix.
Step 8: Reconstruct frames into the final watermarked Video scene Vsi'.
Step 9: Reconstruct watermarked scenes to get the final watermarked Video clip.

B. Watermark Extraction Procedure:

This proposed algorithm is blind in the sense that it does not need the original video in the extraction process. Therefore, we can extract the watermark image from the watermarked video frames directly as described in details in the following steps:

Step 6: Convert the video frames F' from YCBCR to RGB color matrix.
Step 7: Reconstruct frames into the final watermarked Video scene **Vsi**.
Step 8: Reconstruct watermarked scenes to get the final watermarked Video.

B. Watermark Extraction Procedure:

The proposed algorithm is also blind in the sense that it does not need the original video in the extraction process. Therefore, we can extract the watermark image from the watermarked video frames directly as described in details in the following steps:

Step 1: Divide the watermarked Video clip V' into watermarked scenes Vsi'
Step 2: Process the watermarked frames of each watermarked video scene using SVD as described in steps 3 ~ 8.

Fig.2.(c): Watermark

Fig.2: Snapshots from the video clips and the watermark.

Step 3: Convert the video frame F' from RGB color matrix to YCBCR.
Step 4: Compute the SVD for the Y matrix in frame F'. , this operation generates 3 Matrices (U, S, and V).

As stated earlier, performances of the proposed algorithms are evaluated with respect to three metrics: **imperceptibility**, **robustness** and **payload** [21][22].

Step 5: inverse the pixel value for 5 pixels in each odd block used in the embedding process in The U matrix if it is used in

A. Imperceptibility Performance: the embedding, or in the V matrix, such as x= 1/ pixel value. Imperceptibility means that the perceived quality of the video **Step 6:** Extract the embedded watermark from the integer part clip should not be distorted by the presence of the watermark. of x. 395 Lama Rajab, Tahani Al-Khatib and Ali Al-Haj. As a measure of the quality of a watermarked video, the peak **Step 7:** Construct the image watermark WVsi by cascading all signal to noise ratio (PSNR) is typically used. In our work, the watermark bits extracted from all frames. watermark was embedded in the video according to the two **Step 8:** Repeat the same procedure for all video scenes. algorithms described sections three and four. The average

VIII. EXPERIMENTAL RESULTS AND PERFORMANCE

PSNR for the all frames of the three watermarked scenes was **Evaluation:** 48.1308. This high PSNR value proves imperceptibility of the We evaluated the performance of the two proposed video proposed algorithms. watermarking algorithms, with their different variations, using

B. Robustness Performance: two colored host video clips. Each of the two video clips was Robustness of a watermarking algorithm is a measure of the partitioned into three scenes with having different number of immunity or resistance of the watermark against attempts to frames. The first clip was partitioned into three scenes with 70, remove or degrade it from the video frames by different types 101 and 85 frames, and was used to evaluate the performance of digital signal processing attacks. The similarity between the of the first algorithm. The second video clip, was partitioned original watermark and the extracted watermark from the into three scenes with 60, 43 and 56 frames, and was used to attacked watermarked video frames was measured by using evaluate performance of the second algorithm. The watermark the correlation factor ρ, which is computed using the following used in our experiments was a binary image. Snapshots from Equation:
the video and the watermark are shown in Figure 2 (a, b & c).

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

(11) Where N is the number of pixels in watermark, w and are the original and extracted watermarks respectively. The correlation factor ρ may take values between 0 and1.

Fig.2. (a): Video clip 1 We evaluated robustness of the two algorithms against the following video attacks: JPEG compression, video frame rotation, noise attacks (Gaussian, and salt and pepper noise), frame dropping and frame swapping & averaging.

(i) JPEG Compression:

The watermarked video frames were compressed with different quality factors. The correlation values indicate clearly the high robustness of the proposed algorithm across all matrices. However, its clearly seen that embedding in the S matrix gives the highest robustness results in the three scenes.

(ii) Video Angular Rotation:

The watermarked video frames for the three scenes were **Fig.2.(b): Video clip 2** rotated with different angles. The correlation values generally indicate robustness of the first algorithm against the video
frames rotation. However, embedding the watermark
diagonal-wise in the V matrix resulted in slightly higher robustness compared to S or U matrices for all angles.

(iii) Gaussian and Salt and Pepper Noises:

Two kinds of common additive noise were added with varying intensities to the watermarked video frames for the three scenes; Gaussian and Salt and pepper. Each noise was tested separately, but showed relatively similar results. Results generally indicate robustness of the first algorithm against addition of Gaussian and salt and pepper noise. Embedding the watermark in diagonal of S matrix resulted in lower robustness compared to V or U matrices for all densities.

(iv) Frame Dropping:

The attackers hope by performing frame dropping attack that the embedded watermark will be degraded or removed without hindering the original video. This is due to the fact that large amount of redundancy exist between video frames, and therefore video dropping should leave the integrity of the original video intact. As seen, even if the attacker drops 60% of the frames, the watermark can still be extracted with an acceptable correlation value. Results also show that embedding the watermark in S matrix achieved relatively better correlation after frame-dropping compared with the other two matrices.

(v) Frame Swapping and Averaging:

Other than the frame dropping attack, we evaluated robustness due to video frame averaging and swapping. Frame swapping was performed by taking two random frames from the video and swapping them, then trying to extract the watermark. While averaging is performed by taking two random frames pixels, then taking their average, and replacing the original pixels with the averaged ones. Results show that embedding the watermark in S matrix achieved better correlation for both attacks than **U** and **V** matrices in the three scenes. Furthermore embedding in **V** showed slightly better results embedding in **U**.

(vi) Robustness of the Second Algorithm:

An embedding in the second algorithm was done block-wise in either the **U** or **V** matrices of each SVD-transformed video frame. The algorithm embeds the watermark pixels into odd numbered blocks of the selected matrix rather than embedding into the diagonal pixels of the matrix. Five locations were chosen in the selected odd-numbered blocks to embed watermark pixels. Therefore, five watermark pixels were embedded in each block in the **U** or **V** matrices. We performed the same robustness experiments which we used for the first algorithm. The results obtained showed a high degree of similarity with the robustness results obtained for the first algorithm. The results are not shown here to avoid redundancy.

(vii) Payload:

Data payload or watermarking capacity for a given host video clip is defined as the number of watermark pixels that can be embedded in the host video without causing any visual distortion in the video. To compare the two algorithms in terms of payload, suppose that we have a scene with 56 frames and an SVD matrix (U, S, V) with a dimension 240 x 240. The payload of the first algorithm can be found by multiplying number of frames by number of diagonal elements in the matrix. This results in 13440 pixels. On the other hand, the payload of the second algorithm is found by multiplying number of frames by number of blocks per frame by number of pixel per frame. This results in 252000 pixels. This shows clearly that the payload of the second block-wise algorithm is much larger than the first algorithm. Therefore, the second algorithm could be easily recommended to be adopted when large watermarks are needed in video watermarking.

IX. CONCLUSION

There is need for watermarking in order to achieve copyright protection. The video watermarking is very much different from image watermarking. In the present paper, a brief review of current technologies and SVD transform is used. DWT based video watermarking scheme with Scramble watermark is proposed. This method is inadequate for general use. There are currently different tools offering this watermarking. There is a need to improve its robustness.

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