Resolving ownership rights of video data using visible and invisible watermarking in DWT-SVD domain

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Abstract. This paper addresses the concern of video piracy and also resolves ownership rights. Piracy entails utilizing, modifying and sharing the data without owner concern. Identifying the owner of the piracy and also the legal owner is difficult. For resolving these problems, this paper employs the prominent technique like watermarking with legal data base creation and SVD in wavelet domain. In addition to that, master key frame selection concept is used for identifying the key frames. Here the problem is resolved by two approaches. That is visible and invisible watermark to the authorized data. The watermark may be legal information about the owner like photo, thumb impression, signature of the owner and legal id. The legal id is the visible watermark and photo, thumb impression or signature of the owner is inserted as an invisible watermark. This methodology resists several video and image processing attacks. The experimental results show that the algorithm produces good perceptual quality and robustness to the watermarked video as well as watermark.

1. Introduction
Digital data distribution becomes very comfortable one due to the evaluation of internet. Any type of multimedia content can be distributed and shared easily with anyone. Multimedia content may be text, image, audio or video. This distribution creates illegal copying of the original data without any constraint. It affects the ownership of the original data. In order to retain the ownership and to protect the copyright information watermarking technique is used. In watermarking, copyright information has been embedded in the original data, without affecting the quality of that data. The watermark may be the owner's details, the perceiver's details or other necessary data. In video watermarking, watermark will be added into the video frames, audio or both. Now a day, the video piracy creates big issues in film industry. From the past survey, indian film industry loses around 2250 crore rupees due to video piracy. Figure 1 briefs the impact of video piracy in India. This survey briefs almost 50% of the film may be unaccountable in India due to the problem of piracy.
The proposed methodology aims at reducing the video piracy and to resolve the ownership rights. Various methodologies are proposed in recent past for video copyright some of the methodologies are discussed below. Majid Masoumi [1] et al proposed a data hiding technique for verifying the ownership rights in frequency based domain. He employs the CDMA techniques with discrete wavelet transform.

![Video Piracy in India](image_url)

**Figure 1.** Video piracy statistics in film industry

The watermark was a binary image, embedded into the high and middle frequency of the wavelet coefficients based on pseudo random number (PRN) sequences. Soayyeh [2] proposed the Chaos-based video watermarking in wavelet domain. In this methodology the image encrypted using chaotic map is used as a watermark which was embedded into the I frames of the DWT coefficients.

Amlan Karmakar [3] employed DCT based video watermarking. The watermark was embedded into the middle level frequency of luminance component based on the Zernike moments of the square blocks. This methodology withstands various attacks by engaging the permutation vector and random number generator. Jiafa Mao et al [4] employed the video fingerprint with scene frame based method for video authenticity. In this technique, 5 successive scene frames are selected from the video which are used to create the video fingerprint. The matching procedure is achieved by binary search methodology.

Po-chyi Su et al [5] proposed a watermarking technique for video streaming. The recipient information was used as a watermark, which was embedded into the specific areas of the video frames. In the extraction process, the feature point and self-similarity of watermark are tied up to detect the watermark successfully. Radu O. Preda et al [6] suggested a methodology for video watermarking. In this, DWT technique was employed and the LH, HL and HH sub bands are selected for embedding the watermark. Quantization technique was applied for decomposition. The watermark data are inserted into the coefficients of the wavelet sub bands with the error correction code.

Divjot Kaur Thind et al [7] proposed DWT-SVD based video watermarking technique. In this, the secret data was embedded into the high frequency sub band of the wavelet decomposition. In this algorithm the secret image was inserted in each frame of the video. Osama S. Faragallah [8] proposed a technique for video copyright protection based on SVD and DWT. The secret data was inserted into the high and middle frequency band of the wavelet. The error correction code was applied in to the watermark data, and it was embedded into the spatial and temporally redundant frames.

Li et al. [12] suggested a dual watermarking technique using contourlet and SIFT transform. This technique was resists for image processing and geometrical attacks.
The above mentioned algorithms and image watermarking methodology [10], [11] are providing security to the image and video data, but they do not give solution to the ownership rights. For resolving this problem, the legal data base is created for the authorized distributors. The inventiveness of proposed methodology is

- To addresses the ownership rights by creating legal data base and embedding visible and invisible watermark to the video.
- To reduce the time complexity by embedding the watermark in the specific key frames in the video, which are effectively selected by key frame selection algorithm.
- The robustness and imperceptibility of video as well as watermark is achieved by adapting SVD and DWT technique for watermark embedding process.

This paper organization is as follows. Sections 2 describe about the proposed methodology, section 3 deals with the results and discussion and section 4 describe about the conclusion.

2. Proposed methodology

The proposed methodology resolves ownership dispute of video copyright using visible and invisible Watermarking in DWT-SVD domain. In this methodology ownership right is achieved in two ways. First the visible watermark is inserted into the video to identify the actual distributor of the source video, which is the legal id of the distributor; it is a primary key of the legal database. The second way is to embed the authorized secret image into the original video by applying DWT and SVD with scene change detection technique. The security is achieved by the legal database. The visible watermark is added in to the source video by video watermark pro software.

2.1 Legal database creation

The proposed methodology is introducing the legal database. It is created by the Owner of the database. The producer can act as the owner and the size depends on the number of distributor involving in the process. Suppose the film is distributed to 4 distributors then, the legal database contains the details of the 4 distributors, like distributor name, image and signature. The legal ID is assigned by the producer. It is formulated by DIST keyword with first three letters of the distributor name followed by a sequence number allotted by the owner based on number of distributor. The distributor image or signature is used as a watermark image; it is embedded into the host video. Sample database is represented in table 1.

2.2 Scene change detection

Authors employ the scene change detection technique for segmenting the frames into different groups based on absolute difference of frame variance (ADFV). It is calculated between the adjacent frames. Before calculating the ADFV, the histogram equalization is obtained for all the frames [9]. The formula for finding the ADFV is as follows:

\[
ADFV_n = |FV_n - FV_{n-1}|
\]

Frame variance (FV) is calculated by

\[
FV_n = \frac{1}{MN} \sum_{a=0}^{x-1} \sum_{b=0}^{y-1} |f^{*\prime}_{n}(a, b) - MADF^{*\prime}_{n}|
\]

where, 
- **n-1** -Successive frame of \(n\)
- **FV** -Frame variance of \(n^{th}\) frame
Table 1. Sample database

| S. No | Name of the Distributor | Distributor Image | Distributor Signature | Distributor Legal ID |
|-------|-------------------------|-------------------|-----------------------|----------------------|
| 1.    | SUNITHA PICTURES        | ![Distributor Image](image1) | ![Signature](image2) | DIST_SUN_001         |
| 2.    | UTVISION PICTURES       | ![Distributor Image](image3) | ![Signature](image4) | DIST_UTV_002         |

2.3 Discrete wavelet transform

The DWT (Discrete Wavelet Transform) separates a video into a lower resolution approximation image (LL) and horizontal (HL), vertical (LH) and diagonal (HH) detail components. The frames in the video are split into one level sub band frames using separable two dimensional wavelet transform. This result in three high frequency sub bands (HL, LH and HH) and one low frequency sub band LL. The LH and HL band is selected for embedding and extraction process.

2.4 Key frame selection

After the identification of different scenes in the video, the frame difference is calculated between the consecutive frames for identifying the motionless frames in the scene. The frame difference is calculated by equation 3.

\[ F_d(a, a + 1) = |F_{a+1} - F_a| \]  

(3)

Only 25% of motionless frames are selected as the master key frame for embedding the watermark. The master key frame selection is done by using frame mean and global mean.

- **Frame mean**: Average pixel values of individual frame in a same scene.
- **Global mean**: Average frame mean of all frames in a same scene.

If the number of motionless frames in a scene is less than 25%, the key frames are selected as a master key frames. Otherwise those are identified by following selection algorithm.

**Algorithm for master key frame selection**

Step 1: Calculate Frame mean of all motionless frames in a same scene (Mf)
Step 2: Calculate Global mean of individual Scene (Mg)
Step 3: IF (Mf > Mg):
    Select as a master frame
Else
    Reject the frame
Step 4: Continue till end of the scene in the host video.
Step 5: Master frames are stored in the master Frame database

2.5 Singular value decomposition (SVD)
It is a mathematical transform used to decompose the real or imaginary matrix. This transform is applied in the source video as well as secret image for further processing. The matrix is divided into one singular values (SVs) and two singular vectors (U and V). In this, SVs are only used in the watermarking process. It is represented as

\[
SVD = USV^T
\]  \hspace{1cm} (4)

2.6 Watermark preprocess
The binary image of the respective distributor is selected as a watermark data. It is scaled based on the size of the video frame. The watermark is divided into number of blocks, which are equivalent to the number of master frames selected in the specific scene.

2.7 Watermark embedding and extraction process
In the watermark embedding, the host video is pre-processed into number of frames then the binary watermark image is divided into number of blocks based on number of master frames available in the each scene. The embedding and extraction process are shown in figure 2 and 3 respectively.

Figure 2. Flow graph of watermark embedding
The master key frame selection process is represented in the selection algorithm. The DWT and SVD are applied in the frames, and then the watermark SVs are added with SVs of master frames in a scene. Next, the inverse SVD and DWT is applied to obtain the watermarked video. Different input videos are tried in the experiment. In the extraction phase the watermarked video is processed, with the help of key frame data base and master key frame, the watermark is extracted from the watermarked video.

**Watermark Embedding Algorithm**

| Input: Video, secret image, Legal database |
|-------------------------------------------|
| **Step 1:** Input video is preprocessed and divided into number of frames. |
| **Step 2:** Apply scene change detection method for identifying various scenes. |
| **Step 3:** Perform 2D-DWT in the frames to decompose the video into four sub bands LL, HL, LH and HH. In this middle frequency band LH, HH is selected for embedding process. |
| **Step 4:** Apply SVD to the LH, HH sub bands. |
| \( X_1=USV^T \) |
| **Step 5:** Identify number of key frames in each scene. |
| **Step 6:** Select the master key frames in each scene for embedding the watermark. |
| **Step 7:** Apply SVD to the watermark Image |
| \( X_2=U_1S_1V_1^T \) |
| **Step 8:** Divide the watermark into number of blocks equivalent to number of master frames in a scene. |
| **Step 9:** Embed the watermark into specific key frames by adding watermark SVs to the key frame Svs. |
| \( V_w=S+K*S_1 \) |
| k is a scaling factor, it is used to controlling the quality of the watermarked video. Here k=0.5 |
| **Step 10:** Obtain Watermarked Scenes from \( V_w \). |
| **Step 11:** Combine all scenes and Perform Inverse SVD and DWT to get watermarked Video |

**Figure 3.** Flow graph of watermark extraction
Watermark extraction algorithm

Input: Watermarked video, mater key frames

Step 1: Watermarked video is preprocessed and divided into number of frames.
Step 2: Apply scene change detection method for identifying various scenes.
Step 3: Apply 2D-DWT to watermarked video.
Step 4: sub bands LH, HH are subjected to SVD to obtain watermarked matrix.
\[ V_w = U_w S_w V_w^T \]
Step 5: Identify by number of key frames and its location in each scene.
Step 6: Extract watermark from each scene.
\[ W' = (S_w - S) / K \]
Step 7: Compare the quality of the watermark retrieved from the each scene.

3. Results and discussion

The experiments are conducted using MATLAB to test the proposed methodology for resolving ownership rights of video data using visible and invisible watermarking in DWT-SVD domain. The News, Foreman and Suzie videos with 30 frames/sec which are available in the standard library are taken as input. The sample input videos are shown in figure 4.

(a) News  (b) Foreman  (c) Suzie

Figure 4. Sample Input Videos

The secret image is an image of the second distributor that is Lena that is used as an invisible watermark. The signature of second distributor is used as a visible watermark that is inserted into the top right corner of the video. The snapshots are shown in table 1. The scene changes in the news video are found by scene change detection algorithm, it is shown in figure 5.
3.1 Assessment of robustness and imperceptibility

The proposed methodology is assessed in terms of robustness and imperceptibility by using various metrics namely PSNR, NCC and BER, SR and SSIM. The formula are as follows.

\[
\text{PSNR}(I, \hat{I}) = 10 \log_{10} \frac{255^2}{\frac{1}{L \times K} \sum_{i=1}^{L} \sum_{j=1}^{K} (I_{ij} - \hat{I}_{ij})^2}
\]  

(5)

\[
\text{NCC} = \frac{\sum_{i,j} W(i,j) \hat{W}(i,j)}{\sqrt{\sum_{i,j} W(i,j)^2 \hat{W}(i,j)^2}}
\]  

(6)

\[
\text{BER}(W, \hat{W}) = \frac{1}{P} \sum_{j=1}^{P} \left| W(j) - \hat{W}(j) \right|
\]  

(7)

\[
\text{SR} = \frac{S}{S + D}
\]  

(8)
Figure 6. PSNR of video

Figure 7. PSNR of watermark

Figure 8. NCC of Watermark

Figure 9. BER of watermark
Figure 10. SR of watermark

Figure 11. SSIM of watermark

The PSNR variants with different attacks of output video and watermark are presented in figure 6 and 7 respectively. The NC, BER, SR and SSIM are measured between the original and extracted watermark which are shown in figure 8 and 9, 10 and 11 respectively. For the purpose of evaluating the performance of the proposed methodology, the resultant values are compared with the different existing algorithms developed by Divjot Kaur Thind et al, Osama S. Faragallah et al, Radu O. Preda et al and Li et al. Compared to other techniques, proposed method yields better results for all the metrics. The PSNR and NCC comparisons are shown in figure 12 and 13.

Figure 12. PSNR comparison of proposed Vs existing
4. Conclusion

The methodology proposed is resolving ownership disputes by legal data base creation. The security of the methodology is improved by using visible and invisible watermarking. The quality of the watermarking process is achieved by DWT and SVD. The time complexity of the overall process is reduced by embedding the watermarks into specific key frames which are selected using key frame selection algorithm. The experimental result shows that the methodology produces good perceptibility and robustness to the watermarked video and watermark.

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