A New Video Watermarking Using Redundant Discrete Wavelet in Singular Value Decomposition Domain

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Abstract

Digital watermarking is an innovation for the hiding a secret information into an object. It can be utilized as copyright protection and secure concern for multimedia and digital information. This article presents a new video watermarking using redundant discrete wavelet transform (RDWT) in singular value decomposition (SVD) domain. Further, it is also computed several image quality metrics lie peak signal-to-noise ratio (PSNR), structural similarity (SSIM) index and root mean square error (RMSE) to disclose the imperceptibility and robustness of proposed watermarking approach compared to conventional approaches. Extensive simulation results show that the proposed algorithm have performed superior to the conventional watermarking algorithms.

Keywords: Digital Watermarking, discrete wavelet transform, singular value decomposition, redundant discrete wavelet and image quality metrics.

I. Introduction

It's a digital world, everything has gotten to be digital now. Consistently Gega bytes of information have been sharing over web. Subsequently, one must need to give the security to the mutual multimedia/digital information. One conceivable arrangement is watermarking, which is a piece of information covering up otherwise called steganography [III-V]. These systems used to install the information to be covered up into the spread media. Along these lines, if the information is replicated by someone, then the concealed information will be duplicated and. There are numerous algorithms which have been proposed for digital image watermarking. Most of the analysts have done their examinations on dim scale image which are 2D images. Be that as it may, the greater part of the organization logos is in multi color and information sharing is likewise should be shading as of late. Subsequently, one
needs to create RGB image watermarking to give security and copyright insurance. RGB watermarking is likewise same as grayscale watermarking, just distinction is here in RGB images there are three components i.e., red, green and blue though dark scale images have stand out component. Be that as it may, there are a few issues brought up in creating RGB watermarking algorithms. As of late, the interest in security of copyrights has been brought up in different fields [III], for example, military, bio-restorative, common, web and bio-metric and so on. Copyright security encases verification, for example, information of possession and their logos in the digital media content without intruding on the perceptual nature of digital images [VIII]. If there should arise an occurrence of any debate, confirmed information is evoked from the digital media and it can be utilized as authoritative proof of demonstrate the proprietorship. Watermarking is the procedure that inserts the information to be shrouded which is called as a digital mark into the digital multimedia questions with the end goal that this watermarked information can be evoked later to make an asseveration about the article. All the digital watermarking plans must satisfy the criteria of imperceptibility and additionally the strength against all assaults for extraction or expulsion of watermark. From the previous decades there are such a variety of algorithms have been executed for digital image watermarking utilizing least significant bit (LSB) [VII, XIV], discrete Fourier transform (DFT) [II, VII], discrete cosine transform (DCT) [VI, XVI], discrete wavelet transform (DWT) [I, XIII, XV]. Later, several hybrid transformations-based algorithms also presented in the literature. However, every one of them are neglected to create higher imperceptibility and absence of perceptual quality. Here in this, an imperceptibility and strong embedding and extraction algorithms have been proposed. Wavelet is more proficient than DCT, DFT and even different transformations. It is computationally effective than other transform techniques. Because of its fabulous spatial frequency restriction properties, it is extremely reasonable to find regions in the RGB image where the watermark information can be implanted imperceptibility. We realize that even after disintegration of RGB frame utilizing the wavelet transformation there exists some amount of association between the coefficients of wavelet.

II. Proposed Watermarking Model

Redundant Discrete Wavelet Transform (RDWT):

The R-DWT is a wavelet transform algorithm intended to defeat the absence of interpretation invariance of the DWT. Interpretation invariance is accomplished by expelling the down samplers and up samplers in the DWT and up inspecting the channel coefficients by a factor $2(j - 1)$ of $j^{th}$ level of the calculation. The R-DWT is a characteristically excess plan as the yield of each degree of R-DWT contains indistinguishable number of tests from the info – so for a deterioration of $N$ levels there is a repetition of $N$ in the wavelet coefficients.

The R-DWT calculation is straightforward and is near the DWT one. All the more absolutely, for level 1, all the ε-pulverized DWT (just two at this level) for a given sign can be acquired by convolving the sign with the proper channels as in the DWT case however without down examining. At that point the estimation and detail
coefficients at level 1 are both of size \( N \), which is the sign length. This can be imagined in the following figure.

![Figure 1: R-DWT decomposition.](image)

The general step \( j \) convolves the approximation coefficients at level \( j-1 \), with upsampled versions of the appropriate original filters, to produce the approximation and detail coefficients at level \( j \).

![Figure 2: Two-dimensional non-decimated wavelet filter bank process](image)

**Splitting Video:**

This work is identified with the image watermarking on video outlines. In any case, before implanting the frame on the video outlines we split every one of the frames from the video as shown in figure 3. Through a basic calculation we acquire the video frames.
To achieve the same RGB message image, it is imperative to isolate the RGB image into its parts and afterward begin the procedure. The message image gives us dark scale Red, Green, Blue components.

**Embedding and Extraction Process:**

The proposed R-DWT-SVD based 3D video watermarking embedding process on video frame is as follows:
Step 1: Select and read 3D video from the MATLAB current directory.

Step 2: Split the input watermarking video into number of frames and select a cover frame in which we want to embed the message.

Step 3: Select and read the watermark image.

Step 4: Using R-DWT, decompose the cover frame $F$ into 4 subbands named LL, HL, LH, and HH.

Step 5: Separate R, G and B components from obtained LL and apply SVD to get singular components $U, S$ and $V$ for separated RGB components.

Step 6: Apply R-DWT to the watermark as well to obtain four subbands named LL1, LH1, HL1 and HH1.

Step 7: Separate R, G and B components and apply SVD to obtain singular components of decomposed LL1 of watermark image.

Step 8: Now, use watermark embedding as below:

$$S_{Wr} = S_t + \alpha \cdot S_{wr}$$
\[ S_{W_g} = S_{tg} + \alpha \ast S_{w_g} \]
\[ S_{W_b} = S_{tb} + \alpha \ast S_{w_b} \]

Where \( S_{tr} \), \( S_{tg} \) and \( S_{tb} \) denotes the obtained SVD coefficients of LL from step 5 while \( S_{wr}, S_{wg} \) and \( S_{wb} \) are the obtained SVD coefficients of LL1 from step 7.

\[ W_{Llr,gb} = U_{r,gb} \ast S_{W_{r,gb}} \ast V_{r,gb} \]

**Step 9:** Apply the inverse R-DWT to \( W_{Llr,gb} \) and LH, HL and HH to get watermarked frame.

**Step 10:** Now, overwrite the watermarked frame with the original frame to get the watermarked video.

The proposed R-DWT and SVD based 3D video watermarking extraction process on watermarked video frame is as follows:

**Step 1:** Read watermarked frame.

**Step 2:** Apply R-DWT to decompose it into 4 subbands named LL2, HL2, LH2, and HH2.

**Step 5:** Separate R, G and B components from obtained LL2 and apply SVD to get singular components \( U, S \) and \( V \) for separated RGB components.

**Step 6:** Apply R-DWT to the watermark as well to obtain four subbands named LL1, LH1, HL1 and HH1.

**Step 7:** Separate R, G and B components and apply SVD to obtain singular components of decomposed LL1 of watermark image.

**Step 8:** Now, use watermark embedding as below:

\[ S_{Wr} = S_{tr} + \alpha \ast S_{wr} \]
\[ S_{Wg} = S_{tg} + \alpha \ast S_{wg} \]
\[ S_{Wb} = S_{tb} + \alpha \ast S_{wb} \]

Where \( S_{tr}, S_{tg} \) and \( S_{tb} \) denotes the obtained SVD coefficients of LL from step 5 while \( S_{wr}, S_{wg} \) and \( S_{wb} \) are the obtained SVD coefficients of LL1 from step 7.

\[ W_{Llr,gb} = U_{r,gb} \ast S_{W_{r,gb}} \ast V_{r,gb} \]

**Step 9:** Apply the inverse R-DWT to \( W_{Llr,gb} \) and LH, HL and HH to get watermarked frame.

**III. Simulation Results**

This section describes the simulation analysis of proposed watermarking framework which is tested in MATLAB 2018a adaptation with 4GB RAM, we used different cover videos for testing the proposed algorithm. Figure 6 depicts that obtained video watermarking results with DWT methodology where it discloses cover...
frame, watermark image, watermarked frame and the extracted watermark images. Figure 7 and Figure 8 demonstrates that obtained results of DWT-SVD and proposed video watermarking by utilizing same inputs respectively. It is observed that perceptual quality of watermarked frame obtained with proposed approach seems like the cover frame while the watermarked frame of DWT approach has lack of imperceptibility. Therefore, proposed video watermarking algorithm renders enhanced imperceptibility with higher security and lesser error.

Figure. 6 Obtained results of video watermarking using DWT approach (a) cover frame. (b) watermark image. (c) watermarked frame. (d) extracted watermark

Figure. 7 Obtained results of DWT-SVD based video watermarking approach (a) cover frame. (b) watermark image. (c) watermarked frame. (d) extracted watermark
Table 1: Comparison of quality metrics with existing and proposed video watermarking approaches

|                | DWT   | DWT-SVD | Proposed |
|----------------|-------|---------|----------|
| PSNR in dB     | 73.18 | 73.44   | 73.46    |
| SSIM           | 0.968 | 0.987   | 0.9886   |
| RMSE           | 0.056 | 0.0542  | 0.0541   |

Figure 8 Obtained results of proposed video watermarking approach (a) cover frame. (b) watermark image. (c) watermarked frame. (d) extracted watermark

Figure 9 PSNR values of DWT, DWT-SVD and proposed video watermarking approaches

However, the watermarked frames of DWT-SVD and proposed RDWT-SVD seems same but the quantitative analysis disclosed in Table 1 proven that proposed RDWT-SVD algorithm performed superior in terms of quality metrics such as PSNR, RMSE and SSIM index Figure 9, Figure 10 and Figure 11 demonstrates the comparative
graphical representation of PSNR, SSIM index and RMSE with DWT, DWT-SVD and proposed RDWT-SVD watermarking schemes.

![Graphical Representation](image1)

**Figure. 10 SSIM index values of DWT, DWT-SVD and proposed video watermarking approaches**

![Graphical Representation](image2)

**Figure. 11 Comparison of RMSE with DWT, DWT-SVD and proposed video watermarking approaches**

IV. Conclusion

In this, a new 3D video watermarking approach based on RDWT-SVD is proposed to improve the security and imperceptibility of the regular watermarking approaches that have been implemented for RGB and gray images. Furthermore, image quality metrics like PSNR, SSIM index and RMSE also computed to disclose the effectiveness of proposed video watermarking approach. Experimental analysis disclosed that proposed RDWT-SVD outperformed both visually and quality metrically over existing DWT approach and shown superior qualitative performance over DWT-SVD based approach.
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