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SECURED VIDEO WATERMARK SCHEME USING DISCRETE WAVELET TRANSFORM (DWT) AND ATTRIBUTE BASED ENCRYPTION (ABE) ALGORITHM

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ABSTRACT

The widespread usage of the internet in recent years has made it possible for authors to share their content in digital form. The development of digital multimedia technology is evident in internet and wireless applications. The unauthorized duplication of videos without the owner's permission has been caused by the use of online video content that has been downloaded through the World

INTRODUCTION

Today, a sizeable portion of businesses and governmental institutions, including museums, cultural organizations, libraries, for-profit businesses, and organizations responsible for picture archiving and retrieval, invest extensively in new technologies for video digitization Sahu and Sur (2017). Along with its benefits, the rapid advancement of digital technology has also brought forth some issues (Espinoza et al 2019). The issue of copyright protection has arisen as a result of the remarkable ease with which digital content can be copied quickly, flawlessly, and without restrictions on the number of copies. Consequently, the necessity for image authorization, authentication, and security has

Wide Web. To remedy this issue, several watermarking strategies were put forth, whereby a watermark is concealed in the video as proof of ownership. This study applies Discrete Wavelet Transform (DWT) method and Attribute-Based Encryption (ABE), to develop a more secure video watermark model using a video clip with 210 frames of size 352 x 288 and an image of 18 KB size. The model was subjected to several attacks and the result obtained showed a more robust and secured watermarking system.

Keyword: *Discrete Wavelet Transform, Attribute-Based Encryption, Watermark, High-Efficiency Video Coding, Two-Tree Complex Wavelet Transform.*

increased (Roy et al 2019). In recent years, a lot of research has been done on digital watermarking to resolve the aforementioned problems. Other applications of digital watermarking technology include broadcast monitoring, fingerprinting, authentication, covert communication, e-commerce, and e-governance (Nouioua et al 2018). The study of digital watermarking techniques has therefore drawn a lot of attention in recent years.

A watermark is a covert, undetectable signal that is incorporated into the original data so that it is always visible as long as the content's perceived quality is adequate (Saravanan et al 2019). In the event of conflicting ownership claims, the owner of the original data establishes ownership by removing the watermark from the watermarked content (Kaur et al 2016). Digital watermarking is the process of incorporating a message into a digital signal (such as an image, music, or video) and concealing it there (Kothari et al 2019). It is a notion that is similar to steganography in that both techniques conceal a message inside a digital signal (Gufta et al 2018). Their objectives, though, are what set them apart. While steganography uses the digital signal as a cover to conceal the message's existence, watermarking attempts to conceal a message connected to the digital signal's actual content. Patil & Dhawas (2019). Watermarking has existed for several centuries, first appearing in the form of plain paper watermarks and then appearing on paper currency. However, digital watermarking is a very new discipline that has just recently grown, and it is currently utilized for a wide range of purposes (Rawat et al 2016).

Literature Review

Different research offers numerous video watermarking techniques, however, in this section we emphasize the benefits and drawbacks of each methodology. The presentation is organized chronologically, highlighting the literature and methods reviewed.

HEVC/H.265 is a High-Efficiency Video Coding that was proposed by Dutta and Gupta (2017). The suggested solution successfully controls the rise in video bitrate and decline in perceived quality. The suggested framework is resistant to attacks including re-encoding and image processing. Though less secure, the system is resilient and is susceptible to attack.

Joshi et al. (2017) proposed a DWT-DCT and Arnold transformation technique. The proposed algorithm is exceptionally resilient against some attacks and has a higher embedding capacity. Though less secure, the system is resilient and susceptible to cropping attacks.

Liu, Pan & Song (2017) created a DCT method and a fractal encoding technique. Compared to traditional approaches, the method performs better in terms of resilience and peak signal-to-noise ratio. Though less secure, the system is resilient. Attacks are possible against the proposed technique.

Ponnisathya et al. (2017) developed DWT and SVD hybrid system was used. Although the system is robust and less secure, and vulnerable to various cyber-attacks.

Sahu & Sur (2017) devised a DWT, SVD, and scale-invariant feature transform (SIFT). The proposed technique performs better against temporal attacks than the current literature. The system is less secure and vulnerable to attacks.

Shukla & Sharma (2017) proposed Session Management for Asynchronous Message Encryption (SESAME) and DWT algorithms for video watermarking. The technique has a higher level of decomposition, adjusting the algorithm to all real-time video formats, and pinpointing the exact location of the infringement.

Yu, Wang & Zhou (2017) applied HEVC coding standards were used. The video watermarking algorithm based on HEVC is comparatively sparse at present due to the high complexity of the HEVC method.

Asikuzzaman & Pickering (2018) proposed a Spatial domain method for 3D video watermarking. The model is less secured and less resilient.

Bhardwaj, Verma & Jha (2018) proposed a Quantization of the Coefficient Difference and Significant Frame Selection (SFS) method. A notable increase in robustness was seen as compared to other existing techniques, but the imperceptibility was compromised.

Ge et al. (2018) used the DCT, Gabor filter technique, and 3D Harris algorithm. The developed algorithm guarantees high invisibility, but it can also successfully fend off different Time- and Space-based attacks. Though less secure, the system is resilient.

Gupta, Gupta & Chandra (2018) developed a Group Search Optimization (GSO) algorithm for video watermarking. The results are better than when using a different method. The method is less secure.

Nouioua, Amardjia & Belilita (2018) proposed very good transparency was attained using Singular Value Decomposition (SVD), MSVD, and Quantization Index Modulation. These techniques are resistant to many different types of assaults, including filtering, noise reduction, compression, and frame collision. The proposed method provides greater resilience when compared to other methods that may be found in the literature. The system is robust but less secure. It is vulnerable to attack.

Latha, Reddy & Damodaram (2019) implemented a Secret Sharing and Cuckoo Search Algorithm DWT-SVD transform domain. Experimental findings demonstrate that, in comparison to a few related methods, the suggested video watermarking method offers good imperceptibility and is more resilient to attacks. The system is robust but less secure. It is vulnerable to attack.

Esfahani, Akhaee & Norouzi (2019) proposed Two-Tree Complex Wavelet Transform (DTCWT). The proposed strategy is contrasted with cutting-edge techniques used to defend against various attacks. The suggested solution considerably maintains the perceived quality of the original video while being more resistant to various attacks. The method's computational complexity evaluation revealed that it outperforms the other approaches when compared. The system is robust but less secure. It is vulnerable to attack.

Juneja & Bansal (2019) used an Elliptic Curve Cryptography encrypted image is watermarked within the video frames. The findings showed that the proposed model has increased security, robustness, and effectiveness against various attacks. However, the system is vulnerable to some attacks.

Sujatha & Sathyanarayana (2019). The suggested approach is extremely resilient against frame averaging, frame dropping, and noise attacks, according to simulation results. The system is robust but less secure. It is vulnerable to attack

Zhang, Infante & Veeramachaneni (2019) applied Riva GAN. The deep learning-based video watermarking generates watermarked videos with little visual distortion and that are resistant to standard video processing processes. The system is robust but less secure. It is vulnerable to attack

Methodology

The aim of this paper is to use Attribute Based Encryption (ABE) and the Discrete Wavelet Transform (DWT) algorithm to create a more secure and reliable video watermark model. The ABE Asymmetric Encryption with DWT technique has a large embedding capacity, good resiliency, and great computational efficiency which guarantee the confidentiality of the hidden data. This study proposed a better model by fusing the DWT algorithm and ABE encryption. The working of the proposed system is described below:

The watermark embedding and watermark extraction methods are the two primary components of the system. The sending side performs watermark preprocessing and embedding, and the watermarked image is then sent over the internet to the recipient. Watermark extraction and recovery process are done at the other end. The key operations of our suggested plan were encrypting the parameters with an ABE watermark. A low-frequency sub-band was then obtained from the video by applying a one-level discrete cosine transform during the watermark embedding procedure. Singular value decomposition was used to further process the sub-band. Additionally, the sub-single band's value was acquired. The embedding strength of the watermark was controlled by a scaling factor in the addition operation, and an acceptable value could be found by balancing robustness and imperceptibility. A low-frequency sub-band was recreated using this new singular value after it had been deconstructed once again. In the end, the inverse discrete cosine transform was used to create the watermarked movie using the new sub-band.

The architecture of the proposed system is described in figure 1 and 2 below:

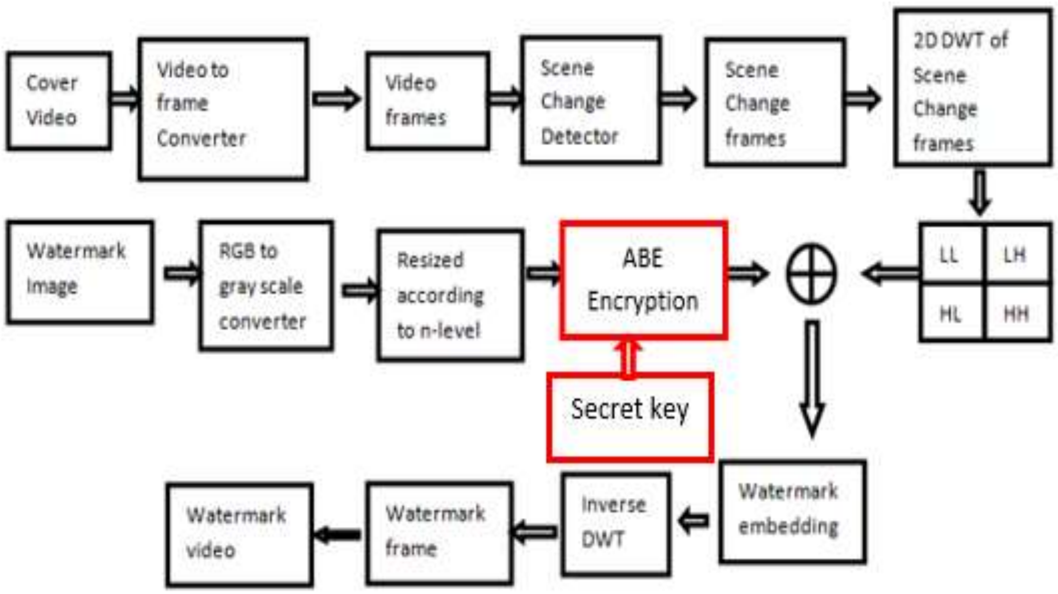

Figure 1: Video Watermark embedding process (Isaac, 2022, p.6)

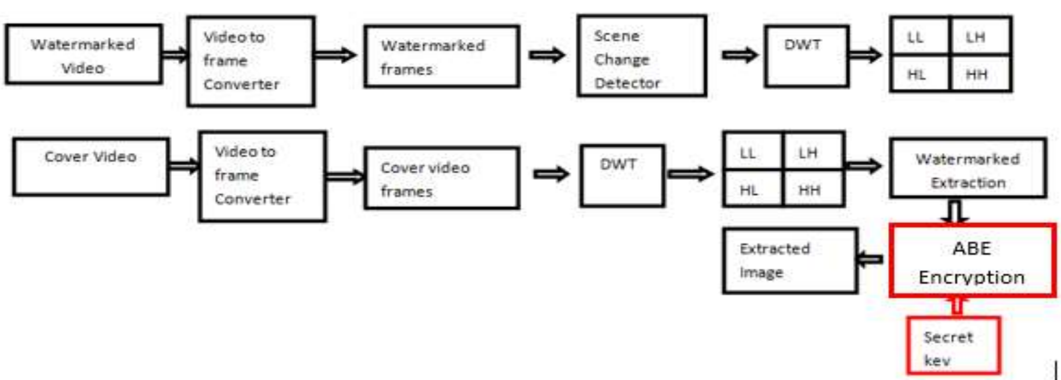

Figure 2: Video Watermark extraction process (Isaac, 2022, p.7)

Evaluation Metric

The system's performance will be assessed using the metrics listed below.

The PSNR is used to determine the peak error between the cover image and the image into which additional information has been incorporated:

$$PSNR = 10 \log 10 \frac{255^2}{MSE} \quad \ldots 1.1$$

The unit of PSNR is dB. And the greater the PSNR value, the less distortion on the Visibility of an image.

Mean Square Error (MSE)

The Mean Squared Error (MSE) refers to the mean square error and X_{ij} is the matrix of the original image, and $\check{X}_{ij}$is the matrix of the watermarked image.

$$MSE = \frac{1}{m.m} \sum_{i=1}^{m} \sum_{j}^{m} \left(X_{ij} - \check{X}_{ij}\right)^2 \quad \ldots 1.2$$

Cross-Correlation Normalized (NC)

NCC is a measure of similarity between the original and extracted watermark. It lies between 0 to 1.

$$NCC = \frac{\sum_{i=0}^{M-1} \sum_{j=0}^{N-1} w(i,j) w_{ext}(i,j)}{\sum_{i=0}^{M-1} \sum_{j=0}^{N-1} w(i,j)^2} \ldots 1.3$$

Where, $w(i,j)$is the original watermark

$w_{ext}(i,j)$ is the refined watermark

Data Collection

The cover video used in this study is a video of a moving train shown in figure 3 below.

Figure 3: Cover Video (accessed 30 May, 2022, www.youtube.com)

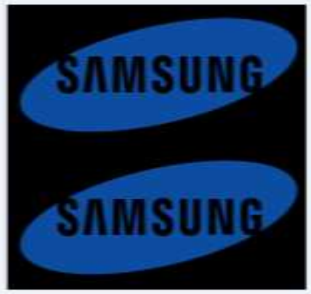

Figure 4: Watermarked image (Isaac, 2022, p.8)

Results and Discussion

In this section, the hybrid watermarking scheme's robustness was simulated on MATLAB 2020a to evaluate the performance of the system.

Test on Robustness

To evaluate the robustness of the method, a simulation with a range of dropping ratio over several frames was used. The message was a video clip with 210 frames of size 352 x 288. The secret image was an 18 KB size picture used in the simulation. There are ten (10) scene changes in the video. Several attacks were used to test the durability of the model such as frame dropping, frame averaging, and lossy compression was conducted. To distort the message, Gaussian sounds were also introduced to the video channel. The model was assessed following the attack to determine the extraction fidelity of the employed watermarking technique. The degree of similarity between the original watermark and the improved watermark was assessed using the Normalized Correlation metric.

Test on Fidelity

Peak Signal-to-Noise Ratio (PSNR), Mean Square Error (MSE), and Normalized Correlation (NC), standard performance evaluation metrics, were used to assess the fidelity test. We demonstrate in the simulation the efficiency of the suggested optimization technique in increasing fidelity. Table 1 below shows the test's results.

Table 1: Evaluation Parameters of the model

Performance Parameter	Value
Normalized Correlation (NC)	0.21232
Mean Square Error (MSE)	4.47E-03
Peak Signal-to-Noise Ratio (PSNR)	1.649190e+02

The outcome of running the watermark model is shown in Table 1. Peak Signal-to-Noise Ratio (PSNR) was 1.649190e+02, Mean Square Error (MSE) was 4.47E-03, and Normalized Correlation (NC) was 0.21232. Table 1 demonstrates that the watermarking approach effectively eliminates the distortion of the video frame caused by the embedding of the watermark.

Experiment with Frame Dropping

The watermarked video was subjected to a frame-dropping attack. This assault was conducted to test the watermark scheme's security. The findings are obtained by dropping various percentages of frames, and they are displayed in Table 2.

Table 2: Frame dropping and Lossy compression evaluation

Description	PSNR	MSE
frame dropping	134.9	0.0900
Lossless compression	87.837	0.0102

The PSNR and MSE of frame dropping are 134.9 and 0.0900, respectively, as shown in Table 2. Lossy compression has a PSNR and MSE of 87.837 and 0.0102, respectively. The method worked successfully, as evidenced by the strong PSNR and low MSE for the Frame dropping. Similarly, the Lossless Compression with High PSNR and Low MSE displays good compression efficiency.

Attack Evaluation

The attacks that were made against the watermark model are listed in Table 3. To test its robustness to noise, Gaussian noise was applied. This displays a respective PSNR of 71.034, -95.4243, and 0.8092.

Table 3: Attack evaluation of the model

Attack	NC	PSNR	WPSNR
Add Noise	0.8092	71.034	95.424
Blur	0.5021	77.373	63.553
Resize	0.71688	66.641	80.64
Cropping	0.78919	66.289	87.981
Rotation	0.85785	72.523	85.785
Median Filter	0.65819	65.819	95.424

The PSNR, WPSNR, and NC for the blur assault, respectively, were 77.373, 63.5526, and 0.5021. Compared to the Add Noise and Blur attacks, the PSNR value for the Resize attack was lower at 66.6419. Blur's WPSNR and NC values of 63.5526 and 0.5021 are lower than Add Noise attack's 95.4243 and 0.8092, despite the PSNR of Add Noise and Blur values being near in magnitude at 71.0383 and 77.373, respectively. The Median filter and Add noise WPSNR have respective values of 95.4243 and 95.4243.

The watermark survives MPEG lossy compression, which removes the details (i.e., the high-frequency components) of the image and video. This is because of the encryption algorithm, which protects the model from attacks and increases its robustness.

The proposed watermark model improved when the watermarked video was resized, as seen in Table 3. The NC, PSNR and WPSNR values for the watermarked scheme after the resizing attacks were 66.641, 80.64, and 0.71688 respectively. This is because as the scaling factor rises, the extracted watermark's inaccuracy also rises, severely affecting the watermark. Higher NC values are produced by the extracted watermark due to the encryption process, which also makes the watermark more resilient by partially overcoming errors in the video watermark.

Scheme Comparison

The results of the DWT and DWT-ABE methods are displayed in Table 4. Both methods have the same NC for the DWT. The MSE of DWT was higher at 101.297, while the MSE of DWT- ABE was lower at 0.004. With 164.91, the PSNR of DWT-ABE is higher.

Table 4: Shows the performance of DWT and DWT- ABE schemes

Scheme	DWT	DWT- ABE
Frame	210	210
Elapse time (sec)	7.9284	12.388
NC	0.65	0.65
MSE	101.297	0.004
PSNR	64.645	164.91

Table 4 shows that the DWT- ABE scheme has a better PSNR and a longer execution time of 12.388.

Features of the Scheme

The proposed watermark scheme is an invisible watermarking scheme. The watermark model has the following features:

- The watermarked image's invisibility: To focus the picture energy on the lower frequency wavelet coefficients, the watermarking approach used low-frequency sub-band DWT coefficients (LL) that are not watermarked. This renders the watermark invisible and prevents it from being seen without the use of an extraction strategy. An encryption technique is used to encrypt the invisible image. But if these coefficients change, the perceptual quality will change as well.
- Blind watermarking was used, therefore retrieving the embedded watermarks does not require the original video. The watermark approach is resistant to the majority of attacks, according to the results from Tables 1, 2, 3, and 4. The experiments demonstrate that the suggested strategy is resistant to the majority of current attacks, yet our scheme still has certain flaws.

Conclusion

Real-time video streaming security issues and online multimedia application security issues have become major security problems. A hot topic in the academic community, widespread video content theft is currently affecting social media and the internet. The lack of multimedia content security and the strength of the employed watermarking system are some of the recognized factors. The research was able to create a reliable and secure model for a video watermark. The model is made up of three phases: embedding, encryption, and extraction. According to Table 4's findings, the model has NC values of 0.81 for Add Noise, 0.67 for Blur, 0.71 for Resize, 0.79 for Cropping, 0.83 for Rescale, 0.77 for Rotation, and 0.91 for Medial filter attacks. This demonstrated that the video watermark method is reliable and can be used for any secure video watermark application.

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