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Survey of Recent Video Watermarking Techniques

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K E Y W O R D S

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A B S T R A C T

With the development of the Internet coupled with expanding the accessibility of multimedia, various copyright issues have resulted. Several researchers have been working on watermarks to provide the security, durability, and a perception of multimedia. This paper a review of some recent works is presented related to video watermarking techniques, this study focuses on the pros and cons of recent video watermarking, areas of application, and the different types and attacks that are standing against these watermarking techniques. The results obtained from this study showed that watermark techniques based on the transfer domain, are more popular than those of the spatial domain.

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1. INTRODUCTION

In the previous quite a long while there has been a dangerous development in media innovation and its applications. This development has heightened the need to construct secure techniques for the lawful circulation of digital content. As computerized interactive media works (video, sound, and pictures) become accessible for retransmission, propagation, and distribution over the Internet, a genuine requirement for security against unauthorized copying and distribution is expanded. Along these lines, there is an ascent in misgivings over copyright protection of advanced substances. The security of digital content has ended up being of extraordinary centrality with the inescapability of the internet. Also, the information concealing innovations for digital data like digital watermarking have pulled in widespread attention [1].

Digital watermarking is a method of concealing a message identified with computerized signals in shifts types, for example, picture, sound, and video inside the sign itself [2].

Watermarks have been used since ancient times to guarantee private data via programmers through the use of various types, for example, text, audio, video, image watermarks. The point of

watermarking the video is to give the personality to the genuine proprietor of that video [3]. Watermarks on video have become an extremely well-known exploration territory and this method gives copyright and safety insurance against robbery, misrepresentation, and abuse of information. A watermark is included in the video in such a way that it cannot be seen by the natural eye and transmitting over the network without any loss in video quality [4].
The following factors have contributed to sparking interest in the field of watermark video education:

- The general public is tainted by the giant security of computerized information, as duplicating of advanced media has gotten similarly simple.
- At this time, the need for a battle against "violations of intellectual property rights" appeared.
- Copyrights assurance should not be disintegrated because of malignant assaults
- Tampering of the computerized information should be covered eventually [5].

Watermarking of video may or may not be visible. Invisible watermarking suggests that the existence of the watermark is scarcely recognizable when viewing the watermark indication. Embedding watermark may get little contortion into the perceptible or obvious parts of the watermarked signal. If the watermark cannot be effectively removed from the watermark tag even after applying basic watermark attacks, it is denoted as strong embedding [6].

2. IMPORTANT ASPECTS OF DESIGNING VIDEO WATERMARK SYSTEMS

A watermarking of the video is a way of including computerized information in a video sequence with the end goal of copyright, annotation, and identification. Advanced information may be content, video, or picture. It is possible to apply image watermark actions to the video watermark, yet because of the repetition of the information, it shows some extra attributes [7].
There are some important aspects of designing video watermarking systems [8]:

- Imperceptibility: Imperceptibility is additionally called invisibility, necessitates that the watermark data embedded in the video can't be seen by the natural eye. All in all, the embedding of watermark data can't altogether influence the visual nature of the video [9].
- Robustness: The essential motivations behind robustness ensure the inserted watermark secures the data from the hackers. Embedded watermarks present in the video even after the attacks. Watermarks could be eliminated deliberately or unexpectedly by straightforward picture handling tasks like contrast or enhancement brightest gamma correction etc. and so on Subsequently watermarks should be vigorous against an assortment of such attacks [10].
- Security: the main indicator of securing digital objects from hackers, embedded information is tamper-proof [11].
- Capacity: The measure of embedded data should be huge enough to extraordinarily recognize the proprietorship of the video [12].

Every one of these prerequisites guarantees that an individual extricating the watermark can get it unaltered even within the sight of assaults with full reliability [13].

3. VIDEO WATERMARKING APPLICATIONS

In the mid1990s, scientists proposed several potential utilizations of digital watermarks whose included picture labeling, Licensed Copyright, fake insurance, and controlled admittance to picture information. A more extensive scope of uses of watermarking of the video, including fingerprinting, copy control, broadcast monitoring, video authentication, and copyright protection were presented in the mid2000s. Most of these incoming requests are generally examined in the accompanying subcategories [14].

I. Fingerprinting

Digital fingerprinting is a technique used to detect digital content ownership. Fingerprints are unique to the digital data owner. A single digital content may therefore have different fingerprints because it relates to different users [15].

II. Copy control

A protected copy is a broadly practiced application in watermarking of video. In this, a watermark is utilized to demonstrate whether video content is copyrighted. A protected copy is a

broadly practiced application in watermarking of video. In such a watermark is utilized to demonstrate if the video content is protected by copyright. That watermark can only be extracted with a heavy degradation of the video succession [16].

III. Broadcast Monitoring

That application is mostly used in commercial advertisements to verify whether the advert has been broadcasted as contracted. It can also be used to trace unauthorized broadcast stations [17].

IV. Video Authentication

A popular video altering software accessible today grant users to effectively mess with video content. Verification methods are therefore required to guarantee the authenticity of the content. One arrangement is the utilization of advanced watermarks. Timestamp, camera ID, and casing chronic numbers are utilized as a watermark and embedded in every single frame of the video stream [18].

V. Copyright protection

For the insurance of intellectual property, the video information proprietor can embed a watermark representing copyright data in the video information. This watermark can help demonstrate proprietorship in a lawful court when somebody has encroached on the proprietor's copyrights. There are numerous strategies for video watermarking for copyright assurance [12].

4. COMMON ATTACKS IN VIDEO WATERMARKING

This part presents an examination of possible attacks on watermarks. Watermark attacks can coordinate attacks within four important categories [19]:

- **Simple_attacks:** in this assault try to crush the embedded watermark by revisions to the whole picture with no endeavor to distinguish and isolate the watermark. Examples include frequency-dependent compression, clipping, noise addition, and modulation.
- **Detection_disabling attacks** endeavor to break a relationship and to make identification of the watermark out of reach. Normally, they make a couple of mathematical adjustments much the same as a transfer in the spatial or temporal direction, zooming, rotation, deletion or inclusion, cropping, or pixel transformation. The watermark in the cover substance can be recovered with upgraded insight by the watermark detector.
- **Ambiguity_attacks** attempt to confuse the detector by creating fake data with a watermark to reduce the effect of the watermark by including several additional watermarks to make it obscure.
- **Removal_attacks**: These assaults surveyed or surmise the watermark from various strange watermarked duplicates, disconnect it and dispose of the watermark. Examples of this attack include the use of a theoretical coding bug of the watermarking method and the collusion attack.

5. TECHNIQUES IN VIDEO WATERMARKING

A handful of video watermarking techniques is in existence; these methods are classified based on their field of operation which is [20].

I. Spatial domain

Embedding watermark in the spatial field is a process of straight adding or modifying the pixel value of the embedding path of the video frame. The computational time of embedding and extraction is less because there is no need for the frame to be transformed [21]. The advantages of spatial domain watermarking are simple, less computational time, and low computational complexity [22]. It is not robust against popular image processing operations [23], A portion of the strategies which utilize spatial domain watermarking are [24]:

1. Least Significant Bit (LSB): the simplest methodology into which the watermark is embedded within the least bit over the original video, in this technique, the least significant bit which conveys a lesser amount of pertinent information is substituted with the watermark bits, which makes it imperceptible. The watermark can be spread all over the video frame or can be in the selected location of the frame. However, the watermark can be simply deleted as the Least Significant Bit is susceptible to various attacks [21].

2. Correlation-based techniques: In this technique, a pseudo-random noise generated is added to the luminance channel of cover media pixels. Add the watermark W (x, y) with the original signal O (x, y), via the accompanying condition.

$$O_w(x,y) = O(x,y) + K * W(o_w,y) \quad .(1)$$

Where K denotes gain operator and $O_w$is the watermarked signal. When the value of K increases the robustness increases, but the quality of the watermark decreases [25].

II. Transforms Domain

The main advantage of transform domain techniques in addressing the setback of the spatial domain [26]. In the transform domain watermarking techniques, firstly the original video frame is transformed from a pre-defined transformation technique. Then the watermark is embedded in the transformation coefficients of the frame. To obtain the watermarked video, the inverse transform of the process used to embed is performed [27]. Video watermarking is unlike image watermarking, due to the availability of extra data that allows information to be more redundantly and reliably to embedding [28]. Some of the frequently used techniques in the transform domain include [29]: (Discrete Fourier Transform (DFT), Discrete Cosine Transform (DCT), Discrete Wavelet Transform (DWT), Singular Value Decomposition (SVD), Discrete Stockwell Transform (DST)).

6. COMPARISON BETWEEN VIDEO WATERMARKING TECHNIQUES

Here a summary of the comparison of video watermarking technologies based on the requirements or features of the digital watermark will be presented.

TABLE I: Comparison of Digital Video Watermarking Techniques based on the requirements of Digital Watermarking [30].

FEATURES	LSB	DFT	DCT	DWT	SVD	DST
Robustness	Low	High	High	High	High	Very High
Imperceptibility	High	Average	Average	Average	Average	Average
Security	Low	High	Average	Average	High	Very High
Data Payload	Less	Average	High	High	High	High
Computational Complexity	Less	Average	Average	Very High	High	Less
Computational Time	Less	High	High	Very High	High	Less
Error Probability	Less	Less	Less	Less	Less	Less

It could be observed from Table 1 that the DST offers the most vital advantages when compared with other techniques.

7. RELATED WORK

Several researchers have used video watermarking techniques. This work incorporates significant previous works that are concerned about Robust Hiding in Digital Video and it begins from 2015 although this topic begins sometime before this date and they are summed up as follows:

- In [31] Rajab et al. presented a study on a digital blind video watermark technique based on Discrete Wave Transfer (DWT) and true Shore decomposition. The schematic diagram begins with the application of a two-level DWT to the video scene followed by a Schur analysis. This technique has proven powerful against a range of standard attacks such as Gaussian, Salt and Pepper, Spin, and some video attacks such as Frame Drop, Cropping, and Center.

- In [32] Senatore et al. A watermarking algorithm for the digital blind for copyright protection have been proposed, whereby the watermark is integrated into the third level of a two-tree compound waveform transformation for each of the two coloring channels, the information in

the video consists of two contributions: a digital watermark and a binary signature, generated from the name required. The selected frame watermark was extracted from it without using the key to generate the watermark: this provides power for time sync attacks, such as frame rate conversion.

- In [33] Thajeel, S.A., he presented a new video watermark scheme based on hybrid shifts to meet watermark requirements, i.e. durability, subconscious, and security. The original video was split into frames for conversion using Slantlet Transform into four subdomains. The HL subdomain was selected for further decomposition using Contourlet Transform (CT), then the low subdomain of the CT was selected for analysis into non-overlapping fixed-size blocks using DCT (Separate cosine transform) in each block. The experimental results showed that the proposed system achieves good sensitivity and high resistance against various attacks.

- In [34] Rizvana. M, Selvaganapathy. They presented a study of the full software implementation of 3-level DWT algorithms and for safer information, a secret key is utilized. During the embedding process, a secret key was utilized for embedding and the same secret key was used during the extraction process. Separate wavelet transformation (DWT) was applied to the video to change the spatial data into spectral data. Single value analysis (SVD) is utilized to accomplish high durability.

- In [35] Asha and Bhagya developed a video watermarking scheme using DWT as a transformation technique and alpha blending technique for embedding and extraction. The input video was segmented into non-overlapping shots and then converted into frames. All the video frames were decomposed using DWT. The watermark was split into four quadrants and decomposed using DWT and embedded into the transformed frames using alpha blending embedding techniques. The modified frames were combined together and IDWT was applied to form the watermarked video. The watermark extraction was achieved using the alpha blending extraction technique. Experimental results show that the proposed scheme recorded a high PSNR and lowest MSE which implies that the scheme is robust.

- In [36] Bhargavi et al. presented a video watermarking solution to keep up quality also robustness through optimization. This strategy adding furtively shared watermark bits to singular values of the discrete wavelet coefficients with an appropriate scaling factor, which is chosen by utilizing the Chaotic Firefly Algorithm improvement method. This technique creates a subtly shared watermark dependent on singular values in the DWT domain to make the system stronger against filtering attacks and video compression techniques. This solution uses a chaotic firefly algorithm to bargain the power and perceptual nature of the contribution alongside SVD and DWT. Ultimately, demonstrated the technique is performing admirably when contrasted with state of the art methods concerning robustness as well as quality at the cost of computation.

- In [37] Ghalejughi et al. presented a study that combined hyperbolic function with DT-CWT (Dual-Tree Complex Wavelet Transform) to improve the multiplicative watermarking method. The author also used the chrominance channel to improve the quality of the watermarking method.

- In [38] Belim, S. V., and P. G. Cherepanov presented a study on a robust digital watermark embedding algorithm that was proposed against any changes in the format of the video container using a separate three-dimensional (3D) cosine transform. To combine the three-dimensional (3D) method based on Koch and Zhao's two-dimensional (2D) method is applied. The digital watermark image and its digital hologram image were used as the embedded information. The inclusion was implemented in the YUV color scheme. The proposed method is proven robust against VCV attacks.

- In [39] Revathi, N., and M. Rukmani, They presented a study on a video watermark technology to secure medical video clips, for the purpose of confidentiality and maintenance

of video medical, is designed to combine medical video frames that include Euclidean distance from the frames. A hierarchical representation of each cohort was created for selecting the mainframe with the entropy value and the likelihood density function (PDF) for the frames. Discrete waveform (DWT) and Single Value Analysis (SVD) improve the exhibition of the watermark embedding process. The exploratory outcomes demonstrated that the proposed scheme has higher durability and unconsciousness against various image and video processing attacks.

- In [40] Srivastava et al. presented a study on a New dual image watermark technology for property rights assurance is proposed which utilizes the Outstanding characteristics of isomorphic transfer, discrete wave transformation, The singular value hashes, and Arnold converts. DWT was additionally applied to the reflection component resulting in sub-frequency bands to be converted by the SVD. Two watermarks were specified for the inserting process while the safety of the suggested algorithm is enhanced by mixing the second watermark through AT. The recreation results indicate the high durability and unconsciousness of the suggested algorithm as it was examined under different attacks.

TABLE II: illustrated the previous researches with their adopted method and its limitations

Reference No.	Method	Advantages	Disadvantages
[31]	Discrete Wavelet Transform (DWT) Schur Decomposition	Excellent Spatial frequency analysis Good energy compaction Robust signal attacks Higher compression ratio	Less robustness against geometric attacks. Noise near edges of images or video frames
[32]	Dual-Tree Complex Wavelet Transform Binary signature	Proved efficacy to ensure robust watermarking. The robustness did not affect the visual quality of the tested videos. The execution times are 41 seconds for the encoding, 1 minute and 46 seconds for the decoding.	Failed to extract binary signature extraction. Other attacks have led to a wrong interpretation of some bits of the embedded binary signature
[33]	Discrete Cosine Transform (DCT) Contourlet Transform (CT) Arnold transformation (AT) Slantlet Transform	Increases the imperceptibility. Good performance in terms of robustness	Limited protection against geometric attacks. Block effect Computationally expensive.
[34]	Discrete Wavelet Transform "DWT" Singular Value Decomposition "SVD"	Good resistance against geometric and signal processing attacks High energy compaction.	High false positive outcomes. Computationally expensive.
[35]	Discrete Wavelet Transform (DWT) Alpha blending technique	Robust Schema depend on high PSNR and low MSE which .	Redundancy makes it more vulnerable to attacks
[36]	Discrete Wavelet Transform (DWT) Singular Value Decomposition (SVD)	The compromise between robustness and quality is achieved. Robustness against various attacks quality	Poor retrieval accuracy Computationally expensive
[37]	Dual-Tree Complex Wavelet Transform "DT-CWT"	Imperceptible and robust to Additive White Gaussian Noise (AWGN)	Limited protection against geometric attacks.
[38]	Three-dimensional (3D) cosine transform	higher robustness and obscurity	Block effect
[39]	Discrete Wavelet Transform "DWT" Singular Value Decomposition "SVD"	Robustness are high imperceptibility against different pictures and videos preparing assaults.	Computational cost

[40]	Discrete Wavelet Transform "DWT" Singular Value Decomposition "SVD" Arnold Transform "AT" Homomorphic Transform "HT"	Resistance against geometric and signal processing attacks (high robustness) high imperceptibility	It lacks shift-invariance Computationally expensive.

8. LIMITATIONS AND ANALYSIS OF VIDEO WATERMARKING

Frome studying and analyzing the most recent research on watermarking in the video, the following are important issues that could be considered during the design of such a system:

1. Wavelet Transform is considered as exceptional spatial frequency, compact energy, and compressed such as in [31], which suffer from tiny degradation that can be noticed in discontinued in gray level. Most of these works are robust against some attacks, especially geometric attacks.
2. Dual-Tree Complex Wavelet Transform is able to strongly protect the copyright of the video content, without any noticeable loss in visual quality as it is used in [32] [37], but it's unsuccessful to compromise the proper binary signature extraction. Also, some attacks led to a wrong interpretation of some bits of the embedded binary signature.
3. In [33] Discrete Cosine Transform (DCT) is used for embedding in the video, it's useful in terms of compaction, which helped to decrease the hiddenness data during watermark embedding, but its Limited safety against geometric attacks and computationally costly.
4. Discrete Wavelet Transform (DWT) and Singular Value Decomposition (SVD) are used to achieve multi-resolution representation and improved energy compression, also to increase robustness towards image processing attacks such as [36] [39]. But as it is known, a higher compression ratio makes the block effect clear, Merging DWT and SVD attempt to reduce the cost of embedding and extraction, But its Computational cost especially with real-time videos.
5. Multilevel level Discrete Wavelet Transform (DWT) is used for watering in the video, such as in [35] which used three Discrete Wavelet Transform in order to compromise between robustness and quality, proven powerful against different assaults while maintaining the quality of video watermarked. In this work, redundancy increases vulnerability to attacks that take advantage of redundant frames, such as tire dropping, tire switching, and tire insertion.
6. Three-dimensional (3D) Cosine Transform used in [38] It is strong against attacks that alter the color and encoding pattern of the video stream, higher robustness of embedding (digital watermarking). But still, the same limitation as [36] [39], a higher compression ratio makes the block effect visible.
7. Arnold Transform and Homomorphic Transform and Discrete Wavelet Transform with Singular Value Decomposition are all gathered in [40] to provide the robust watermark embedding in high-frequency sub-ranges, but it's safer robust against engineering attacks, lacks shift-invariance, and is computationally costly.
8. Result and discussion Spatial domain based-watermarking techniques are widely used due to their simplicity. However, it still suffers from robustness issues against illegal attacks. In transform-based watermarking techniques, the host image or video is transformed to the frequency domain, and then the watermark pattern is embedded using the embedding technique. The main advantage of this technique is its robustness, however, it has limited capacity.

9. ANALYSIS OF COMMON ATTACKS

In this section, recent research is examined to determine the most common attacks that were addressed, including noise adding attacks, spin attacks, frame attacks, engineering attacks, and JPEG compression attacks as in Source [31] [32] [33] [36] [37] [39] [40]. In addition, there are some attacks that have not been addressed. Table 3 shows the attacks against the watermark video according to the sources that were studied with the results.

TABLE III: Video Watermarking Attacks and Results

Reference No.	performance of Attacks	Experimental results
[31]	Robust to noise addition attacks and rotation attacks and frame attacks.	Correlation after noise addition attacks is 0.9772, Correlation after rotation attacks is 1, Correlation after rotation attacks is 0.9999.
[32]	Robust against Geometric attacks (cropping, upscaling); Lossy compression with M-JPEG encoding; Noise addition; Additive attack; Downscaling; Watermark estimation; Temporal frame averaging.	Transparent Watermarking is attained. (PSNR higher than 40 dB and SSIM approximately equal to 0.9)
[33]	Robust against Spatial and temporal Attacks	Average NC = 0.95 and decreases with increase in frame dropping
[34]	None	None
[35]	None	None
[36]	Robust to noise attacks and rotation attacks and JPEG compression attacks.	Avg. Bit Error Rate (BER) is almost negligible i.e. Zero for many attacks.
[37]	robust to Additive White Gaussian Noise (AWGN) as well as geometric attacks	A better tradeoff between capacity and robustness is achieved.
[38]	None	None
[39]	Robust against different Noisy attacks	A better trade-off between capacity and robustness is achieved.
[40]	Robust against geometrical attacks and o JPEG Compression Median Filtering Contrast Enhancement	NC values are quite high is ranging from 0.7706 to 1.00 which is quite remarkable.

In our point of view in finding a mechanism to prevent these attacks is concealed in the frequencies, and it is preferable to use low frequencies because it contains important information, it may be strong and resilient against attacks. Suggested methods that could be taken to reduce the impact of attacks on the Watermark Video:

- Reducing hidden data by using modern techniques of pressure, leads to storage in places that attacks cannot tamper with.
- Relying on video frames to hide with digital audio, so that secret data can be hidden as much as possible.
- Due to the large size of the video, it allows storing data several times even, if part of this data is destroyed; it is possible to make a match between the frames and recover the original data completely.

10. CONCLUSION

Various methods of video watermarking focused on spatial and frequency domain techniques have been studied. The aim of the research is to present a simple framework for digital watermark technology. A digital watermark can actually involve the issue of copyright protection for digital content. Keeping your watermark safe is a big challenge. From this overview, it was found that embedding the watermark in the frequency domain was safer against potential violations. As a prerequisite for the invisible watermark embedding process to preserve raw image detail, the style of the watermark should have simple shapes and textures. If watermark shapes are distorted without significantly affecting the original hosted image, the authorized owner will not be able to prove their presence against the illegal attacks.

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