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Original Article

A State of Art Comparison of Robust Digital Watermarking Approaches for Multimedia Content (Image and Video) Against Multimedia Device Attacks

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Abstract *- The threat of secondhand copyright violation has become a major concern for digital media owners as the quality of multimedia devices such as cameras, cell phones, printers, scanners, and so on improves. Secondhand piracy involves pirates using multimedia devices to duplicate digital content and present it on their behalf. As a result, dealing with it has become critical. Many schemes have been proposed to address ownership conflict, including cryptography, stenography, and watermarking. Watermarking is the most popular technique among researchers, but it still needs much work to resist multimedia device attacks. The uses, problems, and qualities of digital watermarking techniques are explored, studied, and classed. Following that is an overview of several upcoming revolutionary watermarking solutions. A popular topic of discussion is using a strong watermarking method to defend against scan and print attacks. A powerful and robust video watermarking technology that aids in the prevention of piracy and the defeat of camcorder attacks. The topic of attackable multimedia devices is discussed. After discussing each technique, conducted literature research to compile a survey. Finally, summarize the findings and make some suggestions for future research.*

Keywords *- Watermarking, Camcorder Attack, Secondhand piracy, Print and Scan attack, Multimedia device, Frequency Domain.*

1. Introduction

As day-by-day multimedia devices like digital cameras, printers, scanners, cell phones, etc., are increasing in the market, even these devices are coming with high quality. That's why the threat of secondhand piracy may increase. In secondhand piracy, the pirates use multimedia devices to reproduce digital content like images and video and present it on behalf of themselves[1-2], as there is very little effort available to safeguard digital media against secondhand piracy. Watermarking is a popular method of protecting digital media against piracy and copyright infringement. This survey presents insights on the extended mechanism of watermarking to protect digital media against secondhand piracy. Several approaches, such as cryptography, steganography, and watermarking, are utilized for safeguarding multimedia content from unauthorized access. The two words "cryptography" denote "secret writing. Cryptography incorporates communication methods, such as messages termed plaintext and ciphertext, which are encrypted using a specific key, after which the encrypted message is decrypted with the corresponding key. Decryption and encryption are called these methods when working with this key. The main goal of encryption is to prevent unauthorized individuals from understanding the data as it travels from the sender to the recipient. It will remain secured as long as it is encrypted at the receiver's end, but after it has been decrypted, it is no longer secured from unlawful distribution [4]. Steganography is the practice of concealing a message in other data to avoid detecting it. It is derived from the Greek terms steganos and graphein, which mean "covered, concealed, or covered" and "writing," respectively. While steganography differs in intent, watermarking has the additional function of hiding data within the host. This procedure is called marking to identify and claim ownership of certain digital material, such as text, music, photos, video, or 3D models. It can insert any content into the host data, including images, logos, or other information. Steganography is either visible or invisible; it depends on the application. For watermarking, if a secret key is known, then the watermark can be statistically identifiable; if an unknown key is utilized,

then the watermark can be undetectable. Numerous suggestions in the literature on various watermarking techniques and overviews of these strategies are presented in many articles, each focused on a competitor. Many authors, for example, have examined literature descriptions based on applications, technology, and system demands of various multimedia content, such as still images, audio, video, and so on. The watermark is used for various purposes, including authentication and copyright recognition. A covert watermark is added to a signal that is noise resistant. Typically, this is the attribute applied to the signal to identify copyright ownership. "Watermarking" means the process of information with computer assistance that conceals a carrier signal, but the hidden information must not be linked to the carrier signal [3-5].

(a) (b)

Fig. 1 (a) Before watermark and (b) After Watermarked

Imperceptibility: The human observer must not be able to tell the difference between the watermarked and original documents. Three major watermarking algorithm requirements are:

Confidentiality: Satisfactory marking of water should also ensure that flawed watermarks cannot be generated and that the rightful owner is protected with trusted evidence [5].

Robustness: An unauthorized party should not be able to destroy the watermark, i.e. watermark robust to common signal handling and intentional attacks, given any watermark damage or video. In particular, even after signal processing operations on the watermarked image have been applied, it should still be detectable or extractable [6].

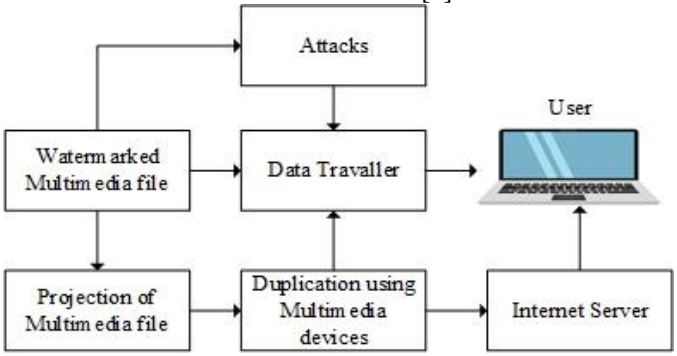

Fig. 2 Illegal Distribution of Pirated Multimedia files after capturing through multimedia devices

Various techniques for protecting images and videos from secondhand piracy have been discussed in the literature. The watermarking techniques discussed in the literature focus on the survival of watermarked messages even after multimedia device attacks, so there should be no confusion that the discussed approach will limit piracy. It will only deter pirates, and if they pirate using multimedia devices, the watermarked message will also be extracted, and the correct owner will be identified [8].

2. Application And Challenges Of Image And Video Watermarking

There are predictions that digital media will have a huge impact on the electronics and entertainment industries due to the revolution it has caused in how images and videos are stored, manipulated, and transmitted. Although digital technology allows easy access to images and videos, one of its main features is the ease with which duplicates can be found. On the other hand, this feature has a negative side effect in that it facilitates easy and illegal multimedia device piracy. Because of this, copyright protection of stored and transmitted digital images is critical. Watermarking is useful in combating the illegal reproduction of images and videos in the following ways [9-13]:

2.1. Authenticate content and objects

Watermarking assists businesses and inspectors who need to ensure that content is original and has not been altered or faked. If the content has been edited, a digital watermark is usually present and continues to be present. Additionally, digital watermarks give your materials an additional layer of security and aid in identifying the source of leaks.

2.2. Monitor Broadcasts & Internet Distribution

In the United States, broadcast television already has a unique digital identity that includes distributor and date and time information. Detection equipment is present in broadcast places. Digital watermarks are often used in the media sector to acquire information such as airing dates, hours, and whether or not the item was played all the way through. It is possible that license compliance, advertising approval verification, and illegal use detection will be incorporated. [7-9].

2.3. Manage Digital Rights

In effect, watermarking is to material (such as photos, music, or video) outside of the DRM (i.e., linking use rules, billing information, and other essential metadata) as connecting content to DRM, linking use rules, and other essential metadata is to the DRM.

2.4. Deter piracy

The information in a digital watermark varies but is often more information about the owner, usage rights, and similar data. It tells whether or not play is allowed and, if so, whether or not duplicates can be made.

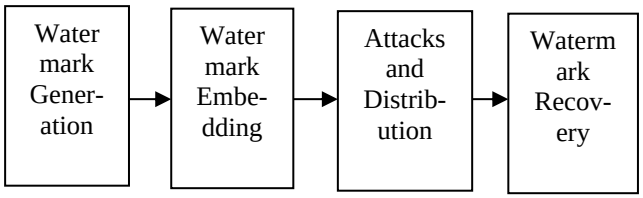

Fig. 3 Block Diagram of Watermarking Process

The major challenges of the watermarking approach are the possible attacks that attackers may apply. Because of that, the embedded watermark may destroy and would not be extracted from the watermarked file. So many watermarking approaches have been proposed in the past, and out of those techniques, some are for images and some for the video file. In each proposed approach, researchers have taken care of the specific and basic attacks [11]. Major attacks that may be applied on watermarked multimedia files are rotation, noise (Gaussian, salt and pepper, etc.), scaling, crop, compression, geometrical attack and many more, which is classified in fig. 3. Attack on watermarked files are mainly classified in two part first is intentional attack, and another one is unintentional attack. In an intentional attack, the pirate applies attacks on watermarked file to destroy the watermark message. In an unintentional attack, it is automatically applied because multimedia devices may be used to duplicate the multimedia files. Unintentional attacks are more hazardous because it destroys the watermark message completely without any preprocessing from pirate [14].

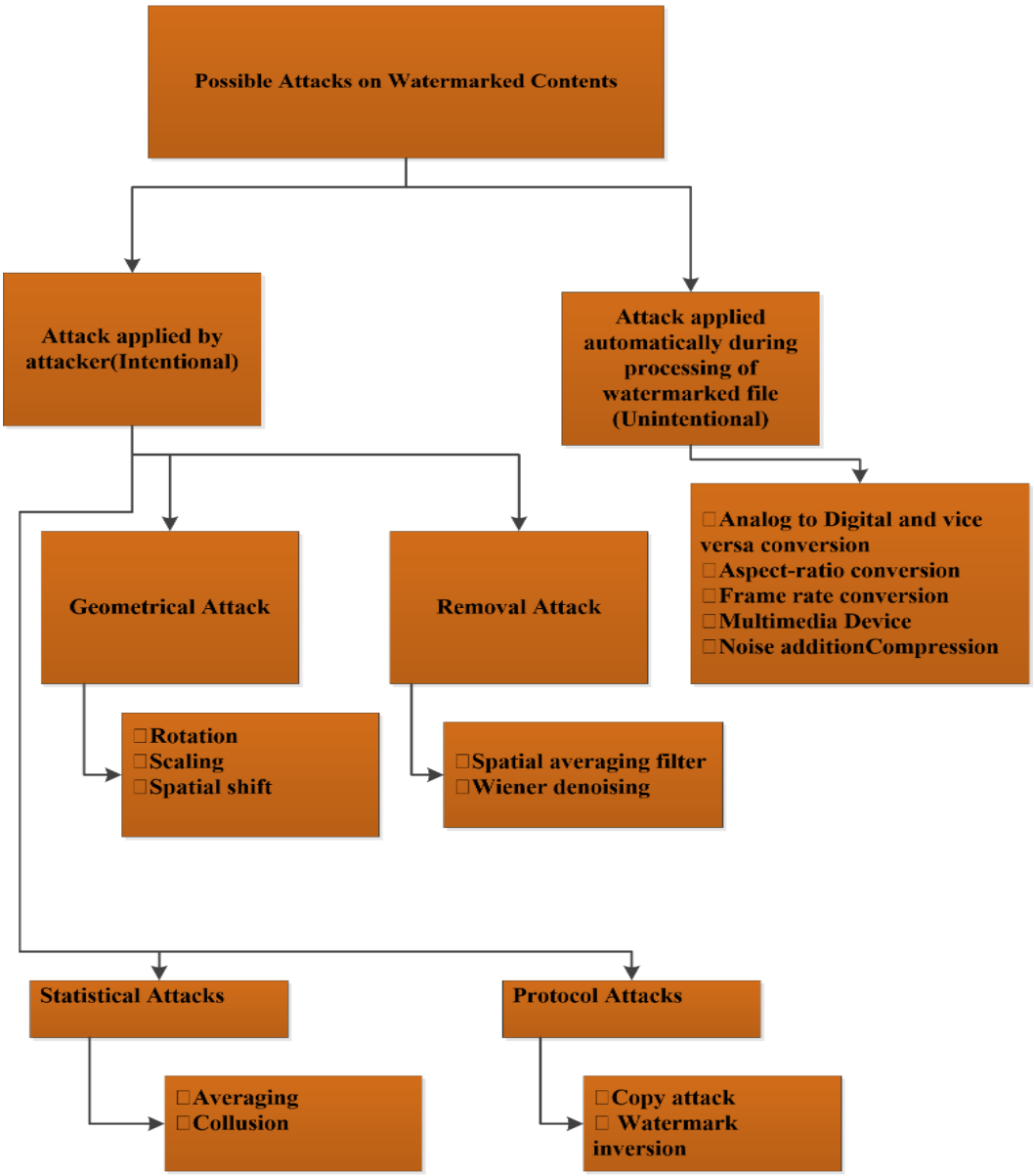

Fig. 4 Classification of attacks on watermarked files.

Watermark can be applied in two multimedia file domains [15-17]: spatial and transform domains or frequency domains. In the spatial domain, the watermarking process is directly applied to the LSB or MSB part of the file. The multimedia file is first converted in the frequency domain in the transform domain using any method like FFT, DCT and DWT. Some, time combination of any two depends on researchers. A comparison of both domains is specified in table I.

Table 1. Comparison of watermarking technique

Parameters	Spatial Domain	Transform Domain
Robustness	Fragile	More Robust
Costing	Low	High
Perceptually	Highly Controllable	Low Controllable
Capacity	High (Image size matter)	Low (1/16 of the host image)
Application	Mainly authentication	Copyright protection

3. Multimedia device attack on multimedia files

In this fast, technology-changing age, day by day, advancement in electronic devices is taking place, and multimedia devices are not exempted from it. Let's compare the last few years' advancements in multimedia devices, mainly printers, scanners, digital cameras, cell phones, etc. We find that nowadays, their qualities are much better than before. These high-quality multimedia devices have now become one weapon for the pirate people. They may use these multimedia devices to duplicate the multimedia files like images and videos. They will duplicate images using print and scan and record the presented video illegally using a high-quality digital or cell phone camera. Piracy of images and video using multimedia devices is almost immune from watermarking technology because of multimedia device distortion. So there is the need arises to make the existing watermarking technology more robust against multimedia device attacks. Researchers have contributed to it, and in this paper, their work result has been presented with a brief amount of technical discussion.

Table 2. Evolution of multimedia devices

Sr. No.	Year	Printer	Scanner	Video Recording Camera
1	1970-80	Inkjet and MX-80 dot Matrix	OCR systems	the first-ever digital camera by Kodak
2	1981-90	LaserJet and DeskJet Printer, and Remanufactured cartridges	Charged Coupled Device Scanner	DS-1P First true Digital Camera
3	1991-00	printer with scanning and fax, and the first six-color photo printer	Contact Image Sensor	First-ever digital SLR by Kodak, Apple Quick Take Camera VP-210 is the world's first phone camera
4	2001-10	Wireless printers and the first monochrome 3-D printer	Hand Held Scanner	first interchangeable-lens DSLR, iPhone with camera
5	2011-21	High-quality 3D printer and, High-quality inkjet and laser printer.	Smart Phone Scanner and 3DScanner	SLR, DSLR Camera and Each phone with a HighDigital camera

4. Multimedia Device attack on image

The printer and scanner are multimedia devices broadly used to duplicate the image so that no watermark message can be detected from duplicated copy. In a Printer and scanner attack, the pirate uses any printer to print the original watermarked file, scan the printed copy, and do some preprocessing to sustain the quality of the image and then present. The watermarked message completely destroyed the duplicate copy because of the print and scan attack, and the conventional watermarking approach was not robust against this attack. So, discussing this attack and presenting a robust algorithm is necessary. Few authors have proposed work against the print and scan attack. In this paper section, proposed work against the print and scan attack is discussed with their efficacy and comparison with others [4, 18, 19].

A DWT-DCT [20-21] composite watermarking technique is presented that is strong against printing and scanning distortions. First, the mid-frequency sub-bands of the original image are obtained using DWT applied to the image. Afterwards, the selected mid-frequency subbands are encoded using a one-dimensional DCT. The resulting coefficients are used to incorporate the watermark. Used a

Genetic Algorithm to find a certain image quality to apply watermarking after insertion. Determine the influence of a modeling algorithm and use that to choose suitable sites for watermarking. The model incorporates noise and nonlinear attack simulations, such as estimation of noise and system identification, in the printers and scanners.

While 3D printing becomes more popular, copyright issues will undoubtedly arise. Conventional protection solutions are ineffective because 3D printing makes such approaches obsolete. A watermarking system described in this study offers the ability to safeguard digital content, not only when it is shared digitally but also when it is transformed into analogue content through 3D printing. Proposed[36] a component resistant to changes in printing direction to apply our watermark. Instead of being considered a significant distortion, the printing artefacts are perceived as templates containing orientation information sent to the watermark detector. An estimating approach also starts by examining the print artefact to determine the printing orientation [19-21].

Fig. 5 Scanned Image and extracted watermark [Chen and Lin]

Table 3. Performance comparison of various watermarking techniques for image

Approach		[2]	[31]	[1]	[32]	[5]
Type of Domain		DWT-DCT	DCT	DWT-DCT	-	Spatial
PSNR (dB)		45.3	40.9	36.89	-	31
Evaluation Parameter		BER	NCC	NCC	NCC	BER
Attacks	Gaussian Noise	-	0.96	0.952	0.693	ERR-4
	Compression	-	0.9725	0.926	-	-
	Salt and Pepper	-	-	-	-	ERR-3
	Print and Scan	0.256	0.725	0.824	0.629	ERR-4
	Rotation	0.104	0.964	0.906	0.60	-
	Cropping	-	0.925	-	0.530	ERR-4
	Upsampling	0.005	-	-	-	-
	Downsampling	0.207	-	-	-	-
	Histogram Equalization	00	-	-	-	-
	Sharpening	0.014	0.99	-	-	-
	Median Filter	0.0125	-	-	-	-
	Blur	0.08	-	-	-	-

5. Multimedia Device attack on video

The quality of video capturing devices is very good nowadays, leading to secondhand piracy of the video in which the pirate records the original presented video through a high-quality camera or cell phone and then circulates it for their purpose. This kind of piracy is known as camcorder piracy. It became a bigger threat to the motion picture industry of the world in which pirates record the presented movie through camcorder devices and then circulate it. Watermarking is the way to resolve the scenario of copyright violation, but the camcorder device recording the recorded video suffers from a geometrical attack like scaling, rotation, viewing angle and cropping. The geometrical attack that automatically applied while recording the video destroyed the watermarked message if it was applied using any conventional approach. So many researchers have proposed a different approach to resolve and deter the second piracy of video [22-25].

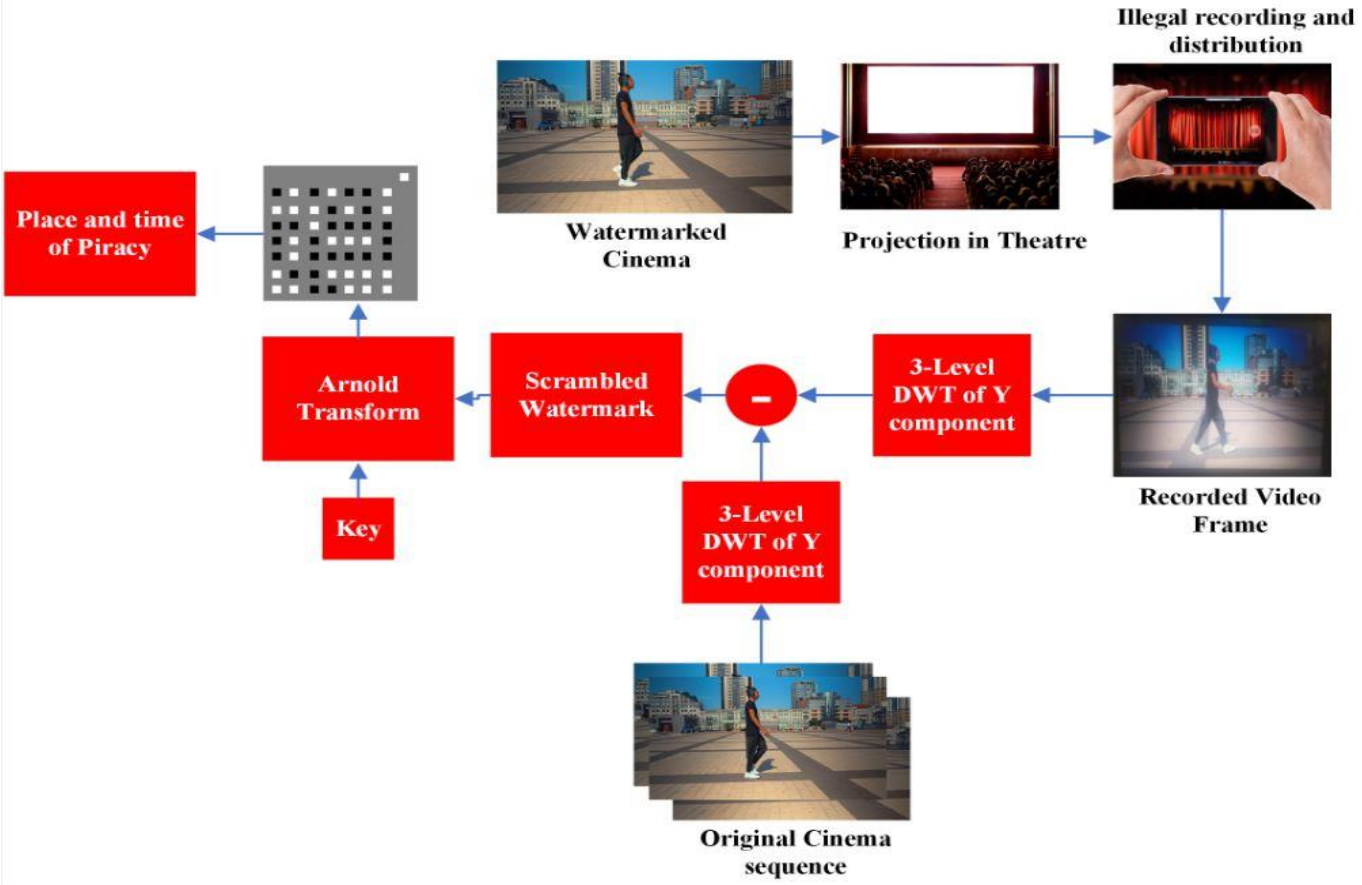

Fig. 6 Process of Digital watermarking in cinema and watermark extraction from a pirated copy

The novel video watermarking method incorporates a spread spectrum for digital cinema security. The device assists the detector in locating the captured message by providing a tool for extracting the embedded message and the estimated position where the camcorder recording is made. Designed to be embedded data for the film release, such as date and time of release and a film identifier. The embedded data appears in the form of background noise in the video. This project aims to keep the noise level to human visual sensitivity [35].

Suggest a highly resilient H.264/AVC HDTV camcorder watermarking approach [27]. Because the material is virtually the same in the next frames of a video, the copyright information is incorporated by finalizing the lighting relationship between the following frames. An adaptive watermark design has been utilized to reduce the image region to be updated to ensure video quality and the resilience of the algorithm, and the embedding strength is adaptive to the enhanced Watson visual model [29-30].

Table 4. Performance comparison of various watermarking techniques for video

Approach		[33]	[20]	[34]	[4]	[4]
Type of Domain		DCT	DCT	DWT-SVD	DT- CWT	DT CWT
PSNR (dB)		46.35	48.94	54.73	47.2	-
Evaluation Parameter		Detecti-on rate	NCC	NCC	NCC	FNR
	Gaussian Noise	100%	0.9923	-	-	
	Compressi-on	100%	0.954	0.95	1.0	00
	Salt and Pepper	-	-	0.89	-	
	Camcorder Recording	99.5%	0.825	0.85	-	0.88

Attacks	Rotation	100%	-	0.98	0.50	0.90
	Cropping	100%	-		0.98	
	Up sampling	100%	-	0.95	0.74	0.52
	Down sampling	100%	-	0.95	-	
	Histogram Equalization	-	-	-	-	
	Sharpening	-	-	-	-	
	Median Filter	-	0.9632	-	-	
	Blur	-	-	-	-	

6. Conclusion

This paper evaluated various watermarking methods for multimedia file contents such as photographs and movies. Here, contributors look at digital watermarking applications and the challenges that come with them, such as imperceptibility and security. As a result of these issues, researchers developed a method for the digital image or video watermarking. Watermark embedding methodologies in various domains were divided into compressed, spatial, and transform. Every process was described, and the studies from which they were derived were scrutinized. Watermarking systems for usage in domain waters were thought to be more durable, stable, and capable of going unnoticed than their spatial and compressed domain-based equivalents. Reviewed geometric-invariant watermarking approaches to survey relevant works. The outcomes of many researchers' recommended approaches have been reviewed and compared. Almost all researchers have tested the suggested algorithm's performance using BER (Bit error rate), PSNR (Peak to signal noise ratio), and NCC (Normalized cross-correlation).

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