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Digital Watermarking-Revisit

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***Abstract*— A digital watermark is a kind of marker covertly embedded in a noise-tolerant signal such as audio or image data. It is typically used to identify ownership of the copyright of such signal. In this paper, I present review on Image Watermarking .Here, I discuss the various factors used in watermarking techniques, attacks, and security and application area where watermarking technique can be used. Also shows a survey on some previous work done in watermarking field.**

***Keywords*— Watermarking, DCT, DFT, DWT, QR codes.**

I. INTRODUCTION

Digital Watermarking started back in 1979, but it was not until 1990 that it gained popularity. No person is credited with founding or inventing the digital watermark. Still in its growth stages today, and with cases like Napster, it is showing more and more reason to have digital watermarking.[3] Digital watermarking is the act of hiding a message related to a digital signal (i.e. an image, song, video) within the signal itself. It is a concept closely related to steganography, in that they both hide a message inside a digital signal. However, what separates them is their goal. Watermarking tries to hide a message related to the actual content of the digital signal, while in steganography the digital signal has no relation to the message, and it is merely used as a cover to hide its existence. Watermarking has been around for several centuries, in the form of watermarks found initially in plain paper and subsequently in paper bills.[4] The hiding process has to be such that the modifications of the media are imperceptible. For images, this means that the modifications of the pixel values have to be invisible. Furthermore, the watermark must be either robust or fragile, depending on the application. By "robust", we mean the capability of the watermark to resist manipulations of the media, such as lossy compression (where compressing data and then decompressing it retrieves data that may well be different from the original, but is close enough to be useful in some way), scaling, and cropping, among others.[5]

II. DIGITAL WATERMARKING TECHNIQUES

The most important properties of any digital watermarking techniques are robustness, security, imperceptibility, complexity, and verification. Robustness is defined as if the watermark can be detected after media (normal) operations such as filtering, lossy compression, colour correction, or geometric modifications. Security means the embedded watermark cannot be removed beyond reliable detection by targeted attacks. Imperceptibility means the watermark is not seen by the human visual system.

Complexity is described as the effort and time required for watermark embedding and retrieval. Lastly, verification is a procedure whereby there is private key or public function (Dittmann, Mukherjee & Steinebach, 2000).Each of these properties must be taken into consideration when applying a certain digital watermarking technique. The following sections describe a few of the most common digital watermarking techniques.

A. Spatial and Frequency Domain

Spatial and frequency domain watermarking are applied to graphic images and text. Spatial domain watermarking slightly modifies the pixels of one or two randomly selected subsets of an image. Modifications might include flipping the low-order bit of each pixel. However, this technique is not reliable when subjected to normal media operations such as filtering or lossy compression (Berghel,1998). Some of its main algorithms are given below:

i). Additive watermarking: The most straightforward method for embedding the watermark in spatial domain is to add pseudo random noise pattern to the intensity of image pixels. The noise signal is usually integers like (-1,0,1) or sometimes floating point numbers.

ii). Least Significant Bit Modification: A digital image version of this analogue image contains sampled values of the function at discrete locations or pixels. These values are said to be the representation of the image in the spatial domain or often referred to as the pixel domain. Spatial embedding inserts message into image pixels.

iii). Texture mapping coding Technique: This method is useful only in those images which have some texture part in it. This method hides the watermark in the texture part of the image. This algorithm is only suitable for those areas with large number of arbitrary texture images and cannot be done automatically. This method hides data within the continuous random texture patterns of a picture.

iv). Patchwork Algorithm: Patchwork is a data hiding technique developed by Bender et alii and published on IBM Systems Journal, 1996[6]. It is based on a pseudorandom, statistical model. Patchwork imperceptibly inserts a watermark with a particular statistic using a Gaussian distribution. A pseudo randomly selection of two patches is

carried out where the first one is A and the second is B. Patch A image data is brightened where as that of patch B is darkened.

v). Correlation-Based Technique: In this technique, a pseudorandom noise (PN) pattern says
W(x, y) is added to cover image I(x, y)
Iw(x, y) = I(x, y) + k*W(x, y)
where K represent the gain factor, Iw represent watermarked image ant position x, y and I represent cover image. Here, if we increase the gain factor then although it increases the robustness of watermark but the quality of the watermarked image will decrease.

Frequency domain watermarking technique is also called transform domain. Values of certain frequencies are altered from their original. Typically, these frequency alterations are done in the lower frequency levels, since alterations at the higher frequencies are lost during compression. The watermark is applied to the whole image so as not to be removed during a cropping operation. However, there is a trade-off with the frequency domain technique. Verification can be difficult since this watermark is applied indiscriminately across the whole image (Berghel,1998). Some of its main algorithms are given below:

i). Discrete Fourier Transform :Fourier Transform (FT) is an operation that transforms a continuous function into its frequency components. The equivalent transform for discrete valued function requires the Discrete Fourier Transform (DFT). In digital image processing, the even functions that are not periodic can be expressed as the integral of sine and/or cosine multiplied by a weighing function. This weighing function makes up the coefficients of the Fourier Transform of the signal. Fourier Transform allows analysis and processing of the signal in its frequency domain by means of analyzing and modifying these coefficients.

ii). Discrete Cosine Transform: Discrete Cosine Transform is related to DFT in a sense that it transforms a time domain signal into its frequency components. The DCT however only uses the real parts of the DFT coefficients. In terms of property, the DCT has a strong energy compaction property and most of the signal information tends to be concentrated in a few low-frequency components of the DCT. The JPEG compression technique utilizes this property to separate and remove insignificant high frequency components in images

iii). Discrete Wavelet Transform Wavelet Transform is a modern technique frequently used in digital image processing, compression, watermarking etc. The transforms are based on small waves, called wavelet, of varying frequency and limited duration. A wavelet series is a representation of a square-integral function by a certain ortho-normal series generated by a wavelet. Furthermore, the properties of wavelet could decompose original signal into wavelet transform coefficients which contains the position information. The original signal can be completely reconstructed by performing Inverse Wavelet Transformation on these coefficients. Watermarking in the wavelet transform domain is generally a problem of embedding watermark in the sub bands of the cover image.

B. The Zhao Koch Algorithm and The Fridrich Algorithm

The Zhao Koch Algorithm and The Fridrich Algorithm watermark techniques are applied to MPEG videos. The Zhao Koch Algorithm embeds a copyright label in the frequency domain of the video. The algorithm randomly selects three coefficients from the discrete cosine transform encoded block and manipulates them to store a single bit of information using a secret key. This single bit information can be the name or address of the owner. The watermark can be easily embedded into the video with minimal operation. Thus, complexity is not an issue. However, the Zhao Koch Algorithm watermark technique is not robust against normal media operations such as scaling or rotation (Dittmann, Stabenau & Steinmetz, 1998).

The Fridrich Algorithm watermark technique is where a pattern is overlaid in the low frequency domain. The pattern is created using a pseudo random number generator and a cellular automation with voting rules. The pseudo random number generator creates a white and black initial pattern that is the same size as the image. A cellular automation with voting rules is then applied until there is a convergence to fixed points. Thus, the pattern is now overlaid into the image. This algorithm is resistant to normal media operations. However, verification using this algorithm is not reliable. This is because the watermark technique does not include detail information about the owner when the pattern is created and overlaid (Dittmann et al., 1998)

III. WATERMARK SECURITY

Watermark security refers to the inability of unauthorized users to remove, detect and estimate, write or modify the raw watermarking bits. In particular, watermark security is not concerned with the semantics of the watermarking bits, but exclusively with the physical presence of the watermarking bits which states that we must assume that the attacker knows the watermark embedding and detection algorithms. The security of watermarking should rely in the secrecy of the keys and only the knowledge of both the algorithm and the keys can break the algorithm. Therefore, we assume that the invader does not have knowledge of the watermarking keys. The aim of an attacker is then to eliminate, remove or mortify the effectiveness of the watermark. An attack is considered successful if the attacker disrupts any stage of the watermarked life cycle; thus, the content owner and the watermarking software have to ensure that each stage of the watermarking is secured.[7]

IV. WATERMARK ATTACKS

An attack is any processing that may impair detection of the watermark or communication of the information conveyed by the watermark. The processed, watermarked data is then called attacked data. There are various different watermark attacks briefly explained below, detailed descriptions can be found in [8, 9]:

A. Removal attack:

Removal attacks aim at the complete removal of the watermark information from the watermarked data without cracking the security of the watermarking algorithm, e.g., without the key used for watermark embedding. That is, no processing, even prohibitively complex, can recover the watermark information from the attacked data. This category includes denoising, quantization (e.g., for compression), remodulation, and collusion attacks. Not all of these methods always come close to their goal of complete watermark removal, but they may nevertheless damage the watermark information significantly.

B. Geometric attack

Geometric attacks do not actually remove the embedded watermark itself, but intend to distort the watermark detector synchronization with the embedded information. The detector could recover the embedded watermark information when perfect synchronization is regained. Subtractive geometric attack involves removing the mark by cropping or digital editing. Whereas, distortive geometric attack attempts to make some uniform distortive changes in the image such that mark become unrecognizable.

C. *Cryptographic attack*

Cryptographic attacks aim at cracking the security methods in watermarking schemes and thus finding a way to remove the embedded watermark information or to embed misleading watermarks. One such technique is the brute-force search for the embedded secret information.

D. *Protocol attack*

Protocol attack aim at attacking the entire concept of the watermarking application. One type of protocol attack is based on the concept of invertible watermarks. The idea behind inversion is that the attacker subtracts his own watermark from the watermarked data and claims to be the owner of the watermarked data. This can create ambiguity with respect to the true ownership of the data. Another protocol attack is the copy attack, the goal of the attack is not to destroy the embedded watermark, but jeopardize the application for which digital watermarks are used. The basic idea of the attack is to copy a watermark from one image to another image, and this without an prior information about the watermarking technology and additional information such as the secret key.

E. Remodulation attack

Remodulation attacks aim at modification of the watermark using modulation opposite to that used for watermark embedding. Assuming the estimated watermark is correlated with the actual watermark, meaning a good estimate could be obtained, the estimated watermark can be subtracted from the watermarked data. Subtracting a very inaccurate estimate of the watermark might decrease the document quality without affecting the watermark too much. On the other hand, correlation-based detection can be defeated by subtracting an amplified version of the estimated watermark.

F. Synchronization removal:

Synchronization removal is to detect synchronization patterns, remove them, and then apply desynchronization techniques, e.g., global affine transformation in the case of image watermarking.

V. PURPOSE OF DIGITAL WATERMARKING

A. Ownership Assertion

To establish ownership of the content.

B. Meta-data Insertion

Meta-data refers to the data that describes data. Images can be labeled with its content and can be used in search engines. Audio files can carry the lyrics or the name of the singer. Journalists could use photographs of an incident to insert the cover story of the respective news. Medical X-rays could store patient records.

C. *Fingerprinting*

Fingerprinting is used to avoid unauthorized duplication and distribution. A distinct watermark (a fingerprint) is embedded in each copy of the data. If unauthorized copies are found, the origin of the copy can be determined by retrieving the fingerprint.

D. Authentication & integrity verification

Watermarks should be able to detect even the slightest change in the document. A unique key associated with the source is used to create the watermark and then embed in the document. This key is then used to extract the watermark and the integrity of the document verified on the basis of the integrity of the watermark.

E. Content Protection

Content owner might want to publicly and freely provide a preview of multimedia content being sold. To make the preview commercially useless, content is stamped with visible watermarks.

F. *Copyright Communication*

Digital watermarking is the process of embedding a persistent digital identity into all forms of media content, providing the means for effective management and tracking of digital assets on the Web. Digital watermarks contain imperceptible digital data that can convey anything the owner chooses, including ownership information, contact details, and usage rights. Watermarks stay with content as it is forwarded and travels across the internet and can be detected at any point to determine the content's unique identity. Watermarks also survive many different file manipulations and transformations, unlike standard metadata that is often lost leaving the content "orphaned."

G. Improved Auditing

Media content of all types — television, music, movies, etc. — continues to proliferate and make its way onto many new consumer devices as well as many

sites across the internet. In a basic auditing application, content owners and distributors can embed unique digital watermarks which serve as an identifier for each licensed asset. The identifier remains embedded in the asset and is conveyed into any licensee compositions that include all or part of the original asset. An auditing application can then quickly and automatically determine the usage of the owner's assets from any composition.

H. Rich Media Enhancement for Mobile Phones

Digital watermarks provide a tremendous opportunity for publishers, brands and marketers looking for new ways to engage consumers with rich media experiences on their mobile phones. The watermarks can be easily embedded into all forms of media content, including magazines, newspapers, packaging, posters, brochures and more. And, unlike 2D barcodes or QR codes that are being used in some mobile campaigns, digital watermarks are imperceptible to humans and do not take up precious space on printed materials, making the technology much more "brand friendly." The digital watermark is a unique digital code that can be easily detected by many of today's most popular smart phones. Once an application is downloaded to the phone, you simply launch the application, hold it parallel and about 6" from the printed content, and the phone will immediately detect the watermark and link the consumer to premium content online. The digital ID in the watermark is matched to a URL in a backend database that is then returned to the consumers' phone.

I. Locating Content Online

The volume of content being uploaded to the web continues to grow as we rely more and more on the Internet for information sharing, customer engagement, research and communication. Digital watermarks are barely discernible digital IDs that can be easily embedded into all forms of media content. The watermarks cannot be seen or heard by humans but are easily detected by computers, networks and a range of digital devices. Internet search services are available that constantly crawl the web looking for uniquely watermarked content. Reports are then generated notifying the owner of where their content was found, allowing them to take any actions deemed necessary.

J. Forensics and Piracy Deterrence

Forensic watermark applications enhance a content owner's ability to detect and respond to misuse of its assets. Forensic watermarking is used not only to gather evidence for criminal proceedings, but also to enforce contractual usage agreements between a content owner and the people or companies with which it shares its content. It provides positive, irrefutable evidence of misuse for leaked content assets.

VI. LITERATURE REVIEW

A. *Jeng-Shyang Pan, Hao Luo, and Zhe-Ming Lu(2006)," A Lossless Watermarking Scheme for Halftone Image Authentication"[12]*

In this paper, authentication watermark is a hidden data inserted into an image that can be applied to detect any unauthorized change of the image. Here a block-based method is used. In this, 512×512 halftone images were selected to test the effectiveness of the method. The halftone image is divided into 4×4 blocks. The original watermark, i.e. the hash sequence of image, is computed by the MD5 hash function. After translating the string into "0-1" sequence, 128-bit digest is obtained. In authentication, the watermark extracted from the watermarked image, and the hash sequence computed from the restored image. When the two sequences are equal, they confirmed the watermarked image suffers no alteration. Both of them are equal to the original watermark.

B. *Ali Al-Haj(2007)," Combined DWT-DCT Digital Image Watermarking"[22]*

In this paper, researcher described a combined DWT-DCT digital image watermarking algorithm. Watermarking was done by embedding the watermark in the first and second level DWT sub-bands of the host image, followed by the application of DCT on the selected DWT sub-bands. The combination of the two transforms improved the watermarking performance considerably when compared to the DWT-Only watermarking approach.

C. *Ching-Tang Hsieh, Yeh-Kuang Wu, and Kuo-Ming Hung," Hybrid Watermarking Scheme for Halftone Images*"

In this paper, they proposed the hybrid watermarking system for halftone images. According to dithered method, the robust spatial domain based watermarks are embedded by alternation dither cells pairs optimized by PSO (particle swarm optimization) algorithm. And the frequency domain based watermarks are embedded by the BPWT (binary pseudo-wavelets transform) algorithm that the two watermarking systems are independent and complement. And modified quality criterion system for halftone images is proposed by the PSO-based human visual filter. From the experimental results, it is shown that the proposed hybrid method is a complementary system and is more robust to malicious attacks such as cropping and scaling. The watermarked image possesses high visual quality and is robust to malicious attacks.

D. K.Ganesan and Tarun Kumar Guptha(2010)," Multiple Binary Images Watermarking in Spatial and Frequency Domains"[13]

In this paper, watermarking scheme provides 24 binary images to be embedded in the frequency domain and also 12 more binary images in the spatial domain. The capacity of the watermark to be embedded in the host image is much greater. Therefore, not only the size of watermark increases, but also ensure acceptable level of security and imperceptibility. Hence, by using the combinational scheme totally 36 images can be embedded in a single RGB image. The results show that embedding of 6 binary images in spatial domain will give better results when compared to 9 or 12 binary images. To increase the level of security different scrambling techniques before embedding in

the host image in different domains are used. The major advantage of this scheme is the increase in the capacity with less distortion.

E. *Qing Liu,Jun Ying(2012),"Grayscale Image Digital Watermarking Technology Based on Wavelet Analysis" [14]*
In this paper, firstly, original image is altered by using the Discrete wavelet transform equal to the 3-layers, so that image is divided into the different sub band and watermarked image is embedded into the in-between frequency sub band. Spread spectrum technology is also used in this paper and blind watermarking technique is used to extract the watermark. Spread spectrum technology hides signal like noise but it increases bandwidth of signal and increases the complexity and blind detection technique is used to extract the watermark.

F. *Arathi Chitla, M. Chandra Mohan(2012)," Authentication of Images through Lossless Watermarking (LWM) Technique with the aid of Elliptic Curve Cryptography (ECC)"[20]*
In this paper, a method for authenticating the image using lossless water marking is being proposed. The proposed method provides high capacity host signal (information) and non altered image by implementing the elliptic curve cryptography and LSB method. The proposed LWM image authentication technique consists of four processing stages namely, i) information authentication, ii) data embedding on image, iii) information and image recovery, and iv)verification. These four stages are consecutively preformed and obtained the watermarked and recovered images. A novel lossless watermarking image authentication technique was proposed in this paper. The technique provides high embedding capacities, allows complete recovery of the original host signal, and the retrieved image have high PSNR value than the conventional technique. The PSNR value of the recovered image proves that the image was not altered and the lossless watermarking procedure was successfully implemented.

G. *M. Kim, D. Li, and S. Hong(2013)," A Robust and Invisible Digital Watermarking Algorithm based on Multiple Transform Method for Image Contents "[18]*
In this paper, algorithm for embedding watermarking is presented. Firstly, the original image is compressed into JPEG image and generates the watermark by using the 2D barcode and scrambling. Secondly, JPEG image is decayed into 3 sub-bands: H, V and D by using 2D-DWT.Thirdly, the DFRNT(discrete fractional random transform) is performed on the sub-band coefficients. And then, watermark image is embed into the sub-band coefficient value using quantization technique. Fourthly, the inverse DFRNT and inverse DWT is performed and lastly watermark JPEG image is obtained. The proposed algorithm has good invisibility and extraction performance, and ensures robustness.

H. *Monika Craig , Prof. Deepak Kapgate(2014)," Effective Copyright Protection of Digital Products by Embedding Watermarking"[16]*
In this paper, SVD-based digital video watermarking algorithm was proposed. In the algorithm, watermarking information was embedded in the diagonal elements of S, U, or V matrices. The algorithm encrypts the binary watermark image by DES which is embedded in the RGB channels decomposed by video. The watermark embedding has no influence to the original video; there is almost no difference between the watermark image extracted from the image containing watermark and the original watermark video. However, embedding in the diagonal elements of matrix produced higher robustness values against JPEG attack.

I. *Vinita Gupta, Atul Barve(2014)," Robust and Secured Image Watermarking using DWT and Encryption with QR Codes"[15]*
In this Paper, algorithm for embedding watermarking is presented by using DWT and encryption with QR codes. Here cover image is selected and DWT is applied on it. A key K is selected to generate the QR code as secret key. QR code and watermark image is encrypted by using XOR operation. Then the encrypted watermark is embedded into the cover image and inverse DWT is applied on the embedded watermark image. For extraction simply apply the DWT on the cover image. This algorithm is quite simple because of using simple X-OR operation for encryption. This algorithm is suitable on different kind of attacks on watermarked images like JPEG Compression, Possion Noise Attack, Salt & Pepper Noise and Gaussian Noise.

J. *Swathi.K, Ramudu.K (2014)," Robust Invisible QR Code Image Watermarking Algorithm in SWT Domain"[19]*
In this paper, watermark is chosen as binary image. In the frequency domain, the embedding process on QR code image using watermark is performed. The QR code image is decomposed by one level using one-dimensional wavelet transformation. To recuperate the embedded watermark there is no need of the original QR code image. The robustness of the algorithm with some attacks such as Salt and Pepper noise, Gaussian noise, and Scaling and Rotating shows extracted watermark with difference magnitude factors. All extracted watermark images contain some visual noise because of the watermark extracting process did not employed the original QR code image.

VII. CONCLUSION

In this paper I have presented various aspects for digital watermarking like overview, security, attacks, techniques and purposes. Apart from it a brief analysis of work done before on digital watermarking (literature review) which can help the new researchers in related areas. In this paper I tried to give the knowledgeable information about the digital watermarking which will help the new researchers to get the utmost knowledge in this domain.

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