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Literature Survey on Watermarking Schemes Using Optimization Techniques

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ABSTRACT

In the world of internet, trillions of bits of information and data are produced in every fraction of second. Thus transferring of the data over the internet needs to be protected from the intruders. Digital watermarking technique has emerged as an innovative technology to protect the data from imposters. This paper focuses different types of transform based approaches and optimization techniques used in digital watermarking. The paper reviews detailed study of particle swarm optimization and proposed methods by taking advantage of combining PSO with different watermarking schemes. The Robustness of the digital watermark implies how effective water marked image against various noise attacks. Thus it has been taken as important parameter for testing the robustness and this can be verified by evaluating NCC (Normalized Cross Correlation value) and PSNR (Peak Signal to Noise Ratio)

Keywords : Watermarking, Particle Swarm Optimization, Discrete Wavelet Transfrom, Discrete Cosine Tranform, Robustness

I. INTRODUCTION

In today's era, the entire transmission, production and distributing of information is digitized and internet has provided the best platform to share information worldwide. However, the digital information can be used or misused any where over the internet with or without the owner's permission. The copyright needs to be embedded in the digital information to protect the content from the intruders. Thus, protection from copyright infringement is a challenging task and hence requires techniques that provide the security to the digital information. Cryptography, Stenography and watermarking have been developed as emerging fields to face the challenges. The research paper basically focuses on different aspect of watermarking. Digital watermarking sets as an extra coating of protection to the digital content so that misusing can be avoided.

Motivation

Due to recent development of digital technology, Piracy is one of the major threats that have affected the information over the internet. Digital watermarking is the technique for embedding the imperceptible and inseparable information behind any digital content for data integrity to prevent the illegal copying, interpretation and distributing of data. In digital watermarking, the bits representing the hidden information or watermark image must be spread throughout the image using lossy compression algorithm in such a manner so that it will not distort the image as well as it cannot easily manipulated by the intruder. Many algorithms have been proposed that has provided innovation and developments in this area. This paper provides a review of digital watermarking schemes in combination with optimization techniques.

The next section provides the architecture of digital watermarking followed by classification of watermarking schemes in section 3. The section 4 provides brief introduction to various optimization techniques that has been used with digital watermarking techniques. The parameters used to evaluate the robustness of watermark are explained in section 5. Section 6 concludes the literature review of watermarking.

II. ARCHITECTURE OF DIGITAL WATERMARKING

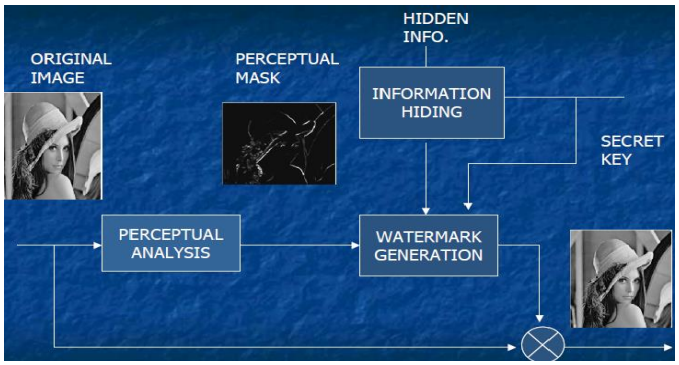

Figure 1. Embedding Segment

The architecture of watermarking is composed of the following units:

1. Water mark Embedding Unit

Firstly, the original image is passed through the perceptual analysis block in order to decide that how many pixels can be altered so that watermarked image will remain undistinguishable from the original image.
Second step determines the type of information to be hidden. Then these information bits are spread with the help of secret key on perceptual mask computed in previous step. Thus, it is very difficult to retrieve the hidden information without having secret key.

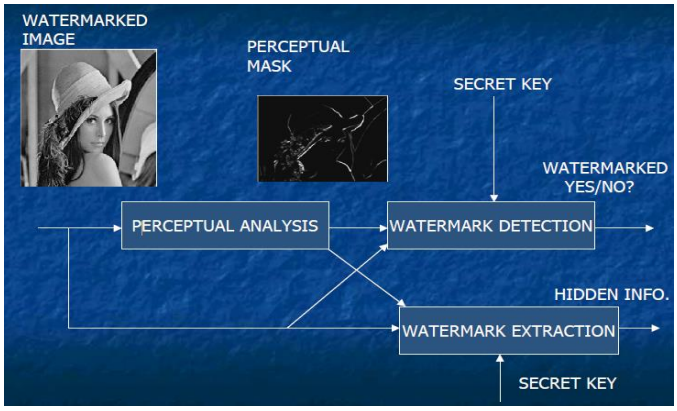

Figure 2. Detection and Extraction Segment

2. Watermark Detection and Extraction Unit

The first step is to detect whether a particular image is watermarked or not. Once the watermark is identified, then hidden information can easily extracted from the water marked image with the help of secret key.
Both the units should be performed in such a way that the quality of the image should be retained to its maximum extent. The next section descries the classification of different watermarking schemes.

III. CLASSIFICATION OF WATERMARKING

Digital watermarking approaches can be classified on the basis of

- Document
- Working domain
- Application
- Robustness
- Characteristics
- Human perception
- Keys

A. On the basis of document, Watermarking techniques can be applied on the following formats:

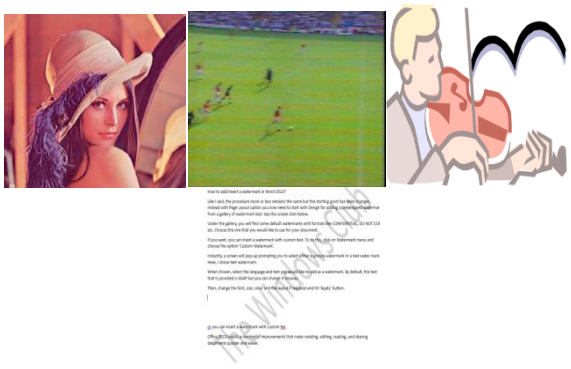

Image Video Audio text

a) Image watermarking: It hides the information bits into the image which can be later extracted to protect the ownership of the author.
b) Video watermarking: It is the updated version of image watermarking. Instead of using watermark inside the image, watermark is embedded in the video stream to control video applications.
c) Audio watermarking: Similar to its application on images and videos, watermarking can be applied to any audio format like mp3, WAV, MPEG etc.
d) Text watermarking: In this method, watermark is applied to any text file like DOC, PDF, TXT, XLS and other text formats so that any changes made to text can be prevented. The watermark

is embedded in the font shape or in the space between characters and line spaces.

B. On the basis of working domain, Watermarking techniques can be categorized as follows:

a) Spatial Domain (Native Domain): In this technique, the water marked image is inserted into the host image by altering the true pixel values in the original image [1][2][3].

b) Frequency Domain: This technique inserts the water mark image into the host image by using the transform coefficients of pixel values in the original image [4]. It is more robust in comparison to spatial domain technique to various attacks on water marked image.[6][7]

Spatial Domain Based watermarking Technique

a) Least Significant Based Schemes: The author [1] summarized the procedure by embedding the water marked image into the least significant bits of pixels located in the proximity of image contours. It is very simple to implement but is vulnerable to many attacks like image manipulation. The author [7] outlined an improvement over LSB method in which an arbitrary quantity is either added or subtracted from each pixel value of the host image. It compares the binary mask bit with least significant bit of each pixel. If both are equal, then addition will be performed otherwise subtraction will be performed.

b) Patch Work Based Schemes: Bender et al [2] proposed two spatial domains based watermarking method for information hiding. The first approach is based on the statistical method called " patch work" in which arbitrary set of pixels are chosen and increases the luminance of one image point by one unit while decreasing the luminance of another image point by one unit. The second approach is "Texture block coding "which is basically a two step process. The primary step is to find a block of arbitrary image texture then, it is copied into another block of image with similar texture. The auto co-relation function is computed to retrieve every texture image.

c) Hash Function Based Schemes: Ping Wah Wong and Nasir Memon [3] embedded by ex-oring the watermark image with output of hash function and the generated output is inserted into the LSB of the image block to create the water marked image. In extraction step, reverse process is followed.

d) Block Based Schemes**:** Kimpan et al [8] recommended spatial domain watermarking based on variable block size. The host image is partitioned into various segments of diverse size thereafter; the water marked image is inserted into these divided segments by interpreting the luminosity of the block. Verma et. al segmented the host image into segment of constant 8 * 8, instead of varying block size. Then, the water marked image is embedded into these blocks by manipulating the pixel intensity of each block.

Frequency Domain Based watermarking Technique

a) Discrete Fourier Transform (DFT): Ruanaidh et al [6] exploits the properties of Fourier transform to embed the watermark in the original image. It is more secure against geometric distortions [9] like scaling, translation and rotation. The author proposed improved form of using log polar coordinates with Fourier transform.

b) Discrete Wavelet Transform (DWT): The primary feature of wavelet is using the idea of frequency domain along with time domain of an image. Thus it is also known as joint time frequency domain. The host image is decomposed into four sub-bands namely LL1, LH1, HL1 and HH1 after applying 1-Level DWT transformation. The LL1 sub band signifies coarse level DWT coefficients while remaining sub bands signifies fine level DWT coefficients. The 2-Level DWT transformation is achieved by further decomposing the sub band LL1 into four sub bands. In general, the image is decomposed into 3N + 1 sub bands consisting of sub bands LLN and LHx , HLx, and HHx , where x varies from 1 to N in N-Level DWT transformation.

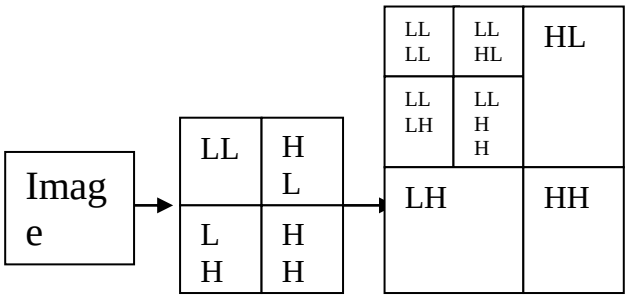

Figure 3. Two-Level Pyramid of DWT

c) Discrete Cosine Transform (DCT): Koch et al [5] developed the DCT domain. The basic steps described in DCT block based watermarking are:-

- Partition the host image I(x,y) into non super imposed blocks of 8 * 8.
- Evaluate the DCT for every block and apply it.
- Apply any arbitrary block selection criteria like HVS.
- Implement the coefficient selection criteria.
- Insert the water mark by changing the chosen coefficients
- Employ the inverse DCT transform on each non overlapping blocks of 8 * 8.

d) Principal Component Analysis (PCA): Mirza et al [10] suggested new frequency domain watermarking scheme for videos. The proposed method inserts an indistinguishable water mark image into different RGB channels independently using PCA transformation. The key element of using PCA method is to use same or different water mark image into these three different RGB channels of the host image thus enhance the robustness against various attacks like rescaling, frame dropping and cropping of the videos.

e) Independent Component Analysis (ICA): Gonzalez et al [11] proposed the concept of ICA in watermarking schemes. The host image and water mark image are considered as independent components. In watermarking embedding process, the components having minimum energy of the host image are substituted by the components having maximum energy of the water mark image. Similarly, in watermarking extraction process, ICA is applied on the de mixing matrices of the water mark and host image.

f) Contourlet Transform: The DWT scheme does not effectively provide smooth curves in the images. Also, it is not suitable for image with more than two level of directionality. In order to overcome these cons, Do & Vetterli[12] presented new technique based on Contourlet transform. Contourlet contains random degree of two's power of directionality along with the features of wavelets. It is considered as "true "2 D transform due to preserving of intrinsic geometric structure of image thus producing better PSNR in comparison to other wavelet transform

Miao & Wang [13] proposed improved a contourlet transformation based on image fusion technique in which the original images are segmented into various contourlet coefficients which are then combined using novel fusion standards. Experiment results shows that the recommended approach is better in preserving contour and texture information than the comparison approaches.

Lu & Do [14] suggested a new Contourlet Transform combined with Sharp Frequency Localization (CTSFL) to compensate the loss of quality in image due to non localization of basis image in frequency domain. It deployed the method of new multi scale decomposition instead of Laplacian transform in order to obtain contourlet coefficients. The deployment of this method yields the basis image with regularity in spatial domain and better localization in frequency domain.

The author [9] recommended recent CTSFL technique by implementing cycle spinning as compensation. The algorithm focused on multi focus image to obtain the image from the effect of blur image. This method gives better results than simple contourlet transform, discrete wavelet transform.

C. On the basis of application, Watermarking techniques can be categorized as follows:

a) Source based watermarking: This approach is employed for the authentication of ownership where unique watermark is inserted into all copies of data.

b) Destination based watermarking: This approach is used in the application where the tracing of buyer is done for the purpose of illegal reselling. Here for each distributed copy a unique watermark for each buyer is used.

D. On the basis of robustness characteristics, Watermarking techniques can be categorized as follows:

a) Fragile watermarking: This watermarking technique identifies the state of fragileness by detecting the percentage of tampering.

b) Robust Watermarking: When the intruder tries to modify the content of water marked image, the water marked image is retained in case of robust watermarking. This approach is resistive against image processing and lossy compressions, common edit processing.

E. On the basis of human perception, it is based on the degree of luminance. Higher the luminance, greater is the visibility of watermark. Watermarking can be categorized as:

a) Visible watermark: Here, the water marked image is visible while viewing the content like stamping a

watermark on paper, (ex.) television channels, like SONY, whose channel logo is visible on the top right corner of the TV picture.

b) Transparent watermarking: Here, the watermark can be inserted in such a manner that it is not visible and detected by normal human eye.

F. On the basis of keys, Watermarking techniques can be categorized as follows:

a) Symmetric watermarking: Symmetric watermarking is a technique in which same keys exploit the process of watering and dewatering the image.

b) Asymmetric watermarking: Asymmetric watermarking is a technique in which two different keys exploit the process of watering and dewatering the image.

IV. WATERMARKING SCHEMES WITH OPTIMIZATION TECHNIQUES

There are two categories of learning machine intelligence: the artificial one that depends on hard computing techniques known as Artificial Intelligence and the computational one that depends on soft computing methods known as Computational Intelligence.

The Computational Intelligence is broadly classified as:

- Fuzzy Logic Systems: This technique focuses on understanding the natural language by the computer. It is widely used in decision making. It is used to handle the partial truth concept which lies between completely true and completely false.
- Neural Network: This scheme is motivated by biological neurons of the brain. It is a collection of artificial neurons which sends signal to one other. This scheme focuses on learning the machine by experience.
- Naturally Inspired Algorithms: These algorithms use the three features: 1) Inspired by the natural phenomena for solving complex problems 2) Uses natural materials like population. 3) Uses the computer system to implement the natural phenomena.

Nature Inspired Algorithms:

1. Evolutionary Algorithms: Example Genetic Algorithm and Differential Evolution
2. Swarm Optimization: Example Particle Swarm Optimization and Ant Colony Optimization.

Evolutionary Algorithm: It is branch of evolutionary computation. It is a generic population based meta heuristic optimization algorithm. It uses the basic concept of mutation (Random mutation, Polynomial mutation), crossover (Linear crossover, blend crossover, simulated binary crossover), selection (Roulette wheel, Tournament) and recombination. It uses fitness function to determine the best solution.

a) Genetic Algorithm: The implementation of Genetic algorithm is based on the Charles Darwin's theory of "Survival of the Fittest" to choose the optimum solution from the set of solutions. The genetic algorithm begins with a set of solutions that serves as the carrier of genetic information called chromosomes which grouped together to form a population. From the population, two random parent chromosomes with best fitness values are chosen. Higher the fitness values, greater the probability of chromosomes to be selected as parents. The parent chromosomes cross over to reproduce a new off spring, and then mutate the new off spring at each locus with the help of mutation. Thus it returns the optimized solution from the newly generated population.

b) Differential Evolution: This theorem was proposed by K. Price and R. Storn [15]. In DE, population of candidate solutions called agents is maintained and new candidate solutions are developed by combining existing solutions. The candidate solution which has best fitness function is selected. Thus it does not require the gradient of the optimized problem. This technique is also suitable for non continuous noise that changes with time.

Swarm Intelligence: Swarm is described as the family of social process. It is basically artificial intelligence method in which un organized collection i.e. population of moving individuals tend to cluster together while each individual appears to be moving in random direction. The basic steps moving towards the computation complexity is to compute the current position, then compare it with the previous position. If the current position is better than the previous ones, then replace it otherwise preserve the current position. The final step is to copy self and others.

a) Ant Colony Optimization: It was proposed by Marco Dorigo in 1992. This scheme is inspired by behavior of ants searching for food. Initially ants wander in a random manner. If any ant from the colony finds food, it communicates with others then all remaining ants will follow the trail instead of wandering randomly.
b) Particle Swarm Intelligence: It was proposed by Russel l Eberhart and James Kennedy in 1995 after getting motivation from the flying behavior of birds. It is population based random probability distribution optimization approach where every individual solution is considered as a" particle" of the swarm in the problem hyperspace. The particle updates its position by four feature vector namely its current position, the best solution obtained so far (pbest), best solution obtained by its neighborhood in the population (gbest), and its velocity.

The above defined optimization techniques have expanded its application by combining with the other approaches of watermarking schemes.

Huang [16] suggested progressive watermarking approach with Genetic Algorithm combined with discrete cosine transform which was more robust against various types of attacks and noises.
Dengeun Lee [17] recommended an innovative watermark extraction algorithm based on Genetic Algorithm and discrete wavelet transform.
Z.wei [18] was proposed a embedding and extracting method with Genetic Algorithm based on DCT domain to enhance the image quality and imperceptibleness properties.
Ali Al-Haj [19] recommended a robust and an imperceptible approach for embedding and extracting of digital watermarking with hybrid combined DCT-DWT.

Stefan Jason and Martin Middendorf [20] proposed new hierarchical form of particle swarm optimization known as H-PSO. In this method, the particle is organized in dynamic hierarchy manner and particles are moved down and up the hierarchy based on best solution obtained till now. Another variant is to assign each particle inertia weight according to their hierarchical level.
Chunming Yang and Dan Simon [21] proposed better solution for particle swarm optimization. Each particle moves its position by considering its own preceding worst position and worst position of the group. Equation to determine velocity and position of the particle remains same as standard particle swarm optimization equation but best position is replaced by worst position.
Hui Wang, Yong Liu, Sanyou Zeng , Hui Li and Changhe Li [22] suggested Opposition based Particle Swarm Optimization(OPSO). In this scheme, each particle will swing between their preceding best value and global best value found so far. The Cauchy's mutation technique is applied on the globally best particle in which global best value of the particle are added to each generation so that search space for the best particle will be extended that will help the particles to move to better positions
Macro A. Montes de Oca and Thomas Stutzle [23] proposed new variant known as fully informed particle swarm optimization (FIPS). In this method, all the neighbors of the particle in the swarm updated its velocity rather than updating the best ones. It is mostly suitable in fully connected network topology.
Yuh-Rau Wang, Wei-Hung Lin and Ling Yang [24] have recommended blind watermarking method using the features of particle swam optimization (PSO) on discrete wavelet transform. In a digital image, the watermark is inserted by quantization of adjacent wavelet coefficients on wavelet trees and can be detected blindly. PSO is used to achieve the imperceptibility and robustness which outperforms the standard PSO, Genetic algorithm and DWT.
Zhang et. al [25] proposed new approach in which chaotic particle swarm optimization was combined with contourlet transform. The enhancement of low resolution quality of images is carried out by using standard deviation and the local means of low frequency sub bands. Thus it increases the overall quality of the image. The use of chaotic particle swarm optimization is to inspect the optimal parameters of image which provides the better quality image and suppress the noise better.
Quraishi et. al [26] recommended an approach which combines the particle swarm optimization with discrete wavelet transform. The DWT scheme was utilized to segment the input image into four different sub bands (LL, LH, HL and HH). Then it is added with the frequency domain of the output image.
Yuanning Liu [27] et al suggested a modified multi swarm PSO (MSPSO). The particles are decomposed into group of subsets called sub swarms. The schedulers are used to control and monitor the sub swarms. They introduced a mechanism to decide the survival of sub swarm called as survival of the fittest. It showed better

performance than genetic algorithm combined with particle swarm optimization.

Ravindra et al [28] proposed the hybrid approach of particle swarm optimization and genetic algorithm. The main advantage of this approach is that it exploits the properties of both spatial domain and frequency domain for enhancement of overall contrast of the image.

Thus, this section provides the applicability of optimization techniques for protecting the copyright information. The next section describes various performance evaluation parameters.

V. PERFORMANCE EVALUATION

Peak Signal to Noise Ratio (PSNR): It is often used for measurement of quality between the host image and the water marked image. Greater the PSNR ratio better is the imperceptibility of the image. Mean Square Error need to be computed to evaluate the PSNR value.

$$\text{MSE} = \frac{\sum_{X,Y}[I1(x,y)-I2(x,y)]^2}{X*Y}$$

$$\text{PSNR} = 10\log_{10}\frac{MAXF^2}{MSE}$$

Where MAXF is the maximum distortion in the input image and X and Y are the number of rows and columns in image. I1 and I2 are host image and watermarked image respectively.

Signal to Noise Ratio (S/N): It is often used for the measurement of relative signal strength to the background noise.

$$\text{SNR}_{\text{DB}} = 10\log_{10}\left(\frac{Psignal}{Pnoise}\right)$$

Where P_{signal} is average power of meaningful information and P_{noise} is average power of unwanted signal.

Normalized Cross-Correlation: It is used to determine the similarity feature between any two images.Greater the value of NCC, greater is the strength of robustness of the derived water marked image. It is used to measure the similarity between the original water mark image and extracted water image.

$$\text{NCC} = \frac{\sum_{i=1}^{x}\sum_{j=1}^{y}[I(i,j)I'(i,j)]}{\sum_{i=1}^{x}\sum_{j=1}^{y}[I(i,j)]^2}$$

Where I and I' are the original and extracted water marked image respectively while x and y are the rows and columns of the water marked image.

VI. CONCLUSION

Digital watermarking has drawn attention in research areas to secure the multimedia data and to protect the intellectual property. The objective of digital watermarking is to develop the indistinguishable image to the human eyes but also contains authentication identification from the perspective of the owner.

The research paper focuses on the different approaches used for digital watermarking. The paper presents the basic steps to be followed to embed and extract the watermark from the image. The survey paper discusses different types of computation intelligence techniques used in digital watermarking. The field of PSO has been growing popular in this area. When combined with other approaches, the result is significantly improved.

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