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ISSN: 0193-4120 Page No. 9662 – 9673

Intelligent Image Watermarking: A Survey

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Article Info
Volume 83
Page Number: 9662 – 9673
Publication Issue:
May - June 2020

Article History
Article Received*: 19 November 2019*
Revised*: 27 January 2020*
Accepted*: 24 February 2020*
Publication*: 18 May 2020*

Abstract:
Digital Watermarking is a technique to verify the authenticity and integrity of the image. With the advent of internet, the authentication of content, copyright violations, and protection against duplication have emerged as an active area research. Several state of the art algorithms addresses this problem still there is a need for more robust and secure water marking technique. Machine Learning algorithms have proved their efficiency is various domains of image processing and is actively used in digital watermarking. Still, there is a need to improve the assurance and performance parameters like imperceptibility, robustness and the capacity to make the data more secure and reliable. This paper summarizes the modern state of the art procedures used for digital watermarking and concludes with future directions.

Keywords*: Image watermarking;machine learning*

1. Introduction

Watermarking is a technique of inserting secret information in to digital signals or to help image to prevent form the copy and unauthorized access. The digital watermarking is classified in two major areas; 1) visible watermarking, and 2) invisible watermarking. A viewable watermarking allows original image to be viewed, it changes the signals overall such that the watermarked signals are totally different from the real signals. An unseen watermarking doesn't allow the original image to be viewed with naked eyes and the partially visible water marking is the blend of the visible and invisible. Therefore, avisible watermarking is integrated in the host image whereas, invisible watermark is integrated to the previously invisible watermark. Since the accessibility to the internet has become easy, people share their data like images or documents on the cloud. Therefore, there has been a major demand for internet safety as people are more concerned about the security and copyrights due to the rapid dispensability of information over the internet. There are several machine learning-based algorithms that are actively reported in literature to solve the problem of digital watermarking. K-means [1], logistic regression [2][1], Linear regression [3], SVM[14] and GA[17]to name a few. These algorithms help to generate accurate and quick results. The artificial intelligence-based algorithms are more popular because of its capacity to handle the complex input and output. Several intelligent watermarking algorithms are presented, however, there is still a need of improvement particularly in terms of strength, volume and the imperceptibility. An increase in the capacity,strength and imperceptibility are hit badly so there is a tradeoff between capacity, strength and imperceptibility. In watermarking performance and accuracy is most important for the security purposes. **Imperceptibility** is defined aserror persuaded during inserting of watermark. The high imperceptibility can be achieved by increasing the Peak signal to noise ratio (PSNR) value.**PSNR** is a ratio between the maximum conceivable power of signal and power of debasing noise that effects the reliability of overall picture.**Robustness**defined as the ability to resist attacks. The goal of attaining strength is achieved by enhancing the **Bit Correct Ratios(BCR)** values.**Capacity**in digital

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watermarking denotes to the total number of bits required for hiding information in the original image while keeping robustness and PSNR reasonable.From the aforementioned discussion, we concluded that the improved imperceptibility with more signal strength, along with the reasonable capacityall essential for scheming the efficient watermarking algorithm. PSNR for the watermarked image is used to compute imperceptibility and is used to serve as an objective degree. The BCR values are used in evaluating robustness.Discrete Cosine transform (**DCT)**is broadly used to translate the dynamic signal into frequency components for reducing the storage size thus, resulting in accelerated data transmission and eradicating repetitive information. Discrete wavelet transform (DWT) is a wavelet transform for which the wavelets are individuallytested. **DFT** Fourier transform is asignificant image processing utensil which is used to decompose an image into its sine and cosine components.**SVD** singular value decomposition is an attractive algebraic transform for image processing images.In this study we will check how machine learning technique applied to the watermarking in order to increase the capacity, imperceptibility and the robustness and which mechanism we can use for the assessment of these parameters.These are the different applications of Image watermarking.Copyright protection, Image authentications, Broadcast Monitoring, copy control, Fingerprinting, Data hiding, Medical safety are to name some few. The present state of the art algorithms for value of watermarked image need to be significantly improved in terms of the limitations like imperceptibility, capacity and the strength, they are the dependent parameters. Currently the main issue is the quality of a watermarked image. Because these properties are inversely proportional to each other which change the visual of the watermarked image and anyone can observe the image is regenrated and the thief can steal the information hidden behind the image. To address this issue, we will use machine learning based technique to improve the performance of the quality of watermarking.There have been the important recently work in watermarking. This motivation is need to provide a copyright protection in digital contents like image, text, video and audio. The basic need is hide information to any other unauthorized persons. Digital media people are concerned about their data privacy and security than we need the hide authorized data.so due to this purpose we need a watermark.*When we apply a watermark in videos, they easily affect the strength and the quality of videos. If we will any changing in image than affect the single may be multiple location of video. So, the significant problem is quality degeneration.*Rest of the paper is organized as follows. Section 2 presents literature review of the current state of the art techniques. Section 3 presents a relative analysis of all the techniques discussed in section 2. The review is concluded in Section 4.

2. LITERATURE REVIEW

In order to make images, video, audio files, text files or 3D models secure for unauthorized usage, we embed information by using digital watermarking. Digital watermarking is accomplished in both domains i.e. spatial domainand frequency domain. Frequency domain watermarking is extensively used in recent state of the art algorithms as we can directly manipulate the contents of image with better understanding.Moreover, when determining about the strength and position of the watermark to be implanted into the image, the human pictorial system characteristics can be taken into account more easily. The section discusses a very brief impression of the state of the art approaches discussed in literature.

2.1Discrete Wavelet Transform (DWT)

Combining two methods DCT and DWT is use to boost the routine of the watermarking algorithmsthat are entirely grounded on the DWT transform [51]. Use of multi-objective optimization method built on PSO lift and regulate the embedded depth to obtain ideal effect. DCT coefficient constraint produce watermarks which are able to resist at certain JPEG compression ratios [8]. DWT permits good localization equally in time and spatial frequency domain. GA clustering algorithm provide significantly better performance than K-Means algorithm [53].To improve imperceptibility androbustness by combining the DWT-DCT algorithm was considerably high [51]. Use of two DWT Levels proved to improve imperceptibility aspect compered to one DWT Level, this methodology proved consistent with the highest average CC value, that is 0.9176 [6]. Using 5-level DWT PSNR increases and MSE decreases equated to 3level DWT [9].The high frequency sub-bands

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were fused using optimal weights obtained by PSO [10].DWT transformation provides image scaling measure with higher flexibility functions [11].DWT-Schur Payload the capacity at the same time maintain theimperceptibility and capacity [12].

2.2 Discrete Wavelet Transform (DCT):

DCT is more suitable scheme for copyright protection, ownership verification and medical imageintegrity [7].To enhance the robustness and imperceptibility the watermarked is embedded byauthentically turning blue channels of the central and adjacent pixels at the same time [14].The qualityof BPWT is better than the Hagit's method for the dither cell obtained by the PSO algorithm processesthe visual transparency and strength [15]. DCT and Discrete Hadamard transform DHT are able toattain near-perfect detection [16]. Converting signal into its fundamental frequency components isdone by DCT, it signifies an image to be sum of sinusoids of fluctuating frequency magnitude [17].Highquality can be obtained by the correct user key and which is carried by visible watermark removalprocess. [18]. Redundant discrete wavelet transformation is useful to test the strength performanceagainst the standard software [19].

2.3 Evolutionary Algorithms:

A lot of work is done according to digital watermarking using the GA, PSO etc. techniques. Manyresearchers work on Image watermarking, so for batter performance they used different algorithms and show batter results they also apply these methods in medical field and some researchers work on intelligence. Different techniques used for image water marking machine learning algorithm are the latest technique used for this purpose. Our main purpose is to boost the eminence of watermarked image by using diverse practice while previously used techniques were GA etc. New machine learning technique proposed which help to improve Impeccability, Robustness and the Capacity at the same time that are not possible with the previous techniques, proposed technique is used to protect the visual data batter than many other approaches, digital watermarking is become most important in very short time. Digital watermarking is the procedure of hiding secret data within the image to secure it form unauthorized access.

2.4 Genetic Algorithm (GA):

DCT coefficient is the best technique for exactness of individually, diminishing bandwidth for thesecurity and verification of the data [20].Sa4 multi wavelet is not only robust to attack it's also ensures the quality of watermarking embed image [21]. After GA optimization by expanding the weightingfactor of capacity the average capacity gets expended, while the BCR value get diminish [22].

2.5 Support Vector Machine and Singular value decomposition (SVM and SVD):

Tiny GA and SVD does not promise an objective detection result and have a very high prospect of a false positive detection of watermarks. SVM modifies blue channels of the central and surrounding pixels at same time. By asymmetric turning, both the strength and imperceptibility of watermarked image can be preserved[23] SVM algorithm is resilient to geometric and frequency attacks and improve the face recognition accuracy at least 10%[24].Needs to eliminate large number of nosey signals to reduce complexity of improved PSO[25]

2.6 Multi-Objective PSO (MOPSO):

MOPSO provides the set of solution in good quality and leave the final choice to the users [25]. An unsupervised algorithm UISMOPSC just process new fitness functions which proves the similarity among each group but yet additionally utilizes the possibility of exterior library of Pareto optimal, so that best particle gained [26]. AMOPSO is compelling algorithm to crack the multi-objective problem which can grow the pareto front of optimization problems quickly and achieve the ideal solution [27]. CMO-MTMV is not touchy to the number of drill cases and it still attains high order precision in situation including small training samples [28]. Strength of Fuzzy clustering technique to existence of tiny clouds and the Gaussian noise is Landsat images.Hybrid particle swarm optimization is an effective &effectual process to crack the multi-objective Flexible job shop scheduling problems especially for large scale problems [29].MOPSO is utilized to get a double computational time by optimization [30].APOMSO has higher convergence speed and batterexploratory capacities then MOPSO

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[31]. Binary change mask is obtained by the MOPSO in Landsat images acquired with different atmosphere conditions [32].MOPSO clustering not only provide the new comparison computing approach dependent on electromagnetic powers, but it's also use to obtains the best number of groups controlled by scale space theory[33]. Thresholds are situated on the histogram to arrange pixel per gray scale class then the pixel are classified according to their brightness [34].

2.7 Particle swarm optimization (PSO):

PSO is a population-based exploration algorithm, initialize through different fleck which randomly flythrough the space. Each of these flecks represent the contender solution to the optimization problem,and has a velocity and different position. The position of the fleck is affected by both best positionsstayed by it and the position of the best district fleck.

$$V_i(n+1) = w_i v_i(n) + c_1 rand_1(\quad)(pbest - xin + c2rand2()(gbest - xin) \quad (1)$$

$$X_I(n+1) = x_i(n) + v_1(n+1) \quad (2)$$

Where, $x_i(n+1) = x_i$represent the current and previous position of i.v_1(n+1) and v_1(n) represent the current and previous velocity of i.

$$V_{in} = w * v_{in} + c_1 * rand() * (b_{in} - p_{in}) + c_2 * rand() * (b_{gn} - p_{in})$$

The iterative plan can useful for particle swarm optimization because the computational complexitygrows linearly with the quantity of edges [35].PSO share many common points of Genetic algorithmbut it doesn't practice the basic machinists such as crossing and mutation [36]. The performance of anoptimal image fusion can be improved by applying curvelet based decomposition methods [37].Theimproved PSO Lewy walk handle more demands because of Lewy walk(LW), demands are directlyallocated to best Data center [38].The excellence of image is enhanced by parameterized revolutionfunction, in which strictures are streamlined by PSO base on an objective function [39].PSO variationis utilized to enhance the erudition for hyper-parameters of conventional neural networks and thebunch centroids of standard fuzzy C-Means clustering respectively to beat the execution boundary[40]. GOP is powerful or vigorous against few attacks such as geometric attacks, frame suppression,density, noise and filtering with high visual quality level [41].Zernike moments have good robustnessand decrementing capability for authentication [42].Hybrid MLPNN-PSO algorithm is useful,suitable, stable , strong and modest recognition technique for human iris recognition [43].2D Otsualgorithm is demoralized to define the classification threshold for precise watermark abstraction[44].K-means algorithm is data dependent algorithm as well as greedy so user needs to specifies classisin advance [45].Alpha blending is used to demonstrate an alpha bitmap and an alpha bit map is that one which hastranslucent and semi-translucent pixels [46]. Region of non interest (RONI) based visiblewatermarking approach reduce the computational complexity and improves the PSNR[47].Evolutionary algorithm is used to accurate the rounding errors [48].The attenuate of substance iscrucial factors to resolve the issue of coping, distributing and modifying the intellectual properties inan illegal way [49].A precise mathematical model in terms of information content-weighted structuralsimilarity index and visual importance is projected to find optimal watermark executing strength [50].

3. STATE OF THE ART SUMMARY

This section gives comparative analysis of the recent state of the art algorithms. Table 1 represents the summary of methodologies along with research contributions and limitations. For a novice researcher this section serves as a birds' eye view for the research domain.

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Table 1: State of the art Summary

Sr #	Author	Methodology	Research Contributions	Limitations
1.	Khaled Loukhaoukha [1]	SVD and Tiny Genetic Algorithm	High prospect of false positive exposure of watermark	Still need to improve with new techniques.
2.	Vasta et. al. [2]	SVM and DWT	Robust to geometric and frequency attacks.	Real world application is still an open issue
3.	Deng et. al. [3]	PSO and LS-SVM.	Only extract the vibrational signals	Only extract the vibrational signals
4.	Ali Al Haj [4]	DWT and DCT	Hybrid DWT and DCT improves performance.	Combination of two transform increase the performance of watermarking algorithm only based on DWT.
5.	Bors and Pitas [5]	Linear DCT constraint and Circular DCT	This Approach is applied on the still images.	Further we can use this for TV and Video System.
6.	Maulik et. al. [6]	GA Clustering	To enhance a quality.	Only use full for four artificial and three real data sets.
7.	Susanto et. al. [7]	2-Leven HWT-DCT	Two Level DWT used to improve the imperceptibility.	
8.	Sood and Goyal [8]	Hybrid GA with DWT and BFO algorithm	PSNR value increased means watermarked image is closer to the real image.	In future we can try this with 5 level DWT and ACO algorithm.
9.	Zhou et. al. [9]	MTMV and CMO-MTMV	More efficient than the other techniques.	CMO-MTMV is not sensitive but it just can achieve high accuracy in scenarios involving in small training samples.
10.	Dey et. al. [10]	Multi objective PSO and ACO	Multi objective technique based on binary PSO and ant colony optimization used to enhance the quality of threshold and PSNR.	Only useful for gray scale images.
11.	Swaraja et. al. [11]	DWT-Schur/DCT-Schur	Payload the capacity at the same time maintain the imperceptibility and capacity.	In future can be used for security and payload simultaneously.

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12.	Kumaran et. al. [12]	Two-dimensional discrete wavelet transforms	Secure and Robust.	Only robustness is ensuring with the proposed technique.
13.	Loan et. al. [13]	DCT	Robustness	Not applicable for real time applications
14.	Yen et. al. [14]	Support Vector Machines (SVMs)	To offers high PSNR of watermarked images and low extraction error rate.	Only use 128 bits in training SVM.
15.	Hsieh et. al. [15]	Particle swarm optimization (PSO)	To improve Robustness.	This algorithm is only robust for the halftone images.
16.	Li Chen [16]	DCT and DHT for error detection.	Not band limited.	According to comparison time domain watermarking is perfect but not robust for the quality factor.
17.	Venkateswarlu et. al. [17]	Arnold Transform AT, DWT and DCT	Double watermarking is used to get the high robustness of the watermarked images.	Only useful for grayscale images.
18.	Espinoza et. al. [18]	Semi blind gray scale image watermarking technique with RDWT, NSCT and SVD.	Strength is achieving by extracting watermark from reconstructed. cover image.	Only applied on the medical images.
19.	Roy et. al. [19]	RDWT-DCT	Increased watermark capacity.	Satisfactory results only for gray scale images.
20.	Bedi et. al. (Bedi, Bansal, & Sehgal, 2010)	Particle swarm Optimization (PSO)	To hiding fingerprinting image together.	Not applicable for real time application
21.	Pan Yinghui [21]	Sa4 multi-wavelet, PSO	Focus on imperceptibility and good quality.	Focus on imperceptibility and good quality.

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22.	Huang et. al. [22]	Genetic Algorithm	To improve Robustness, capacity and imperceptibility together which is not possible yet.	Only suitable for few applications
23.	Singh and Rathore[23]	Classical wavelet transforms CWT, DWT	Robust against intentional and unintentional attacks.	Applicable for Horizontal, vertical and diagonal directions only
24.	Zhang et. al. [24]	Hybrid PSO algorithm is used to solve the job scheduling problem	This process is an efficient and effective for multi-objective problems.	This complex scheduling problem still needed the more effective algorithm.
25.	Liu et. al. [25]	Optimized Otsu multi threshold division based on fireworks algorithm,	Highly strong against various attacks.	This algorithm is only helpful when the number of thresholds is small.
26.	Amini et. al. [26]	Vector based unseen markov model (HMM)	Highly robust against various attacks	Shift sensitivity is still an open research area
27.	Kasban[27]	Karhunen Loeve Transform (KLT), Discreet Hartley Transform.	Improved robustness & suitable for copyright protection.	Need to improve the impartibility and capacity.
28.	Paoli et. al. [28]	MO-PSO	Robust and secure.	High computational cost
29.	Niu and Shen[29]	AMO-PSO	High convergence speed and better examining capability.	PCA is used to acquire an expressive measurement.
30.	Kusetogullari and Yavariabdi[30]	Fuzzy MO-PSO	Provide high strength watermarked image.	Only robust to thin clouds and Gaussian noise.
31.	Liu et. al. [31]	Multi-objective particle swarm optimization (MOPSO)	Robust against attacks.	Multi clustering problem and Optimization objective function needs improvement
32.	Arulraj et. al. [32]	Multi-objective Particle swarm optimization (MOPSO)	Better quality of watermarked image.	Only useful for automatic thresholding

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33.	Chander et. al. [33]	New variant of PSO, iterative scheme to obtain initial threshold using Otsu's method.	This algorithm is useful with PSO because computational complexity grows linearly	Only applicable for gray scale images
34.	Benyamina et. al.[34]	PSO, Multiprocessor systems on chip (MSoS)	Better quality of watermarked image.	PSO need to improve.
35.	Lodhi et. al. [35]	Hybrid constrained PSO based approach, Spectral Angle Mapper (SAM-PSO)	For mapping of pixels quantitively PSO and SAM is used.	Computationally complex
36.	Nathan et. al. [36]	DWT-PSO and optimized multi scale image fusion	Fusion scheme is suitable for all kind of images.	Only useful for color multi focus images.
37.	Butt et. al. [37]	Particle swarm optimization. Improved PSO with Lewy walk.	Velocity of particle is updated with levy walk because of early convergence.	Traps in local minima
38.	Gorai and Ghosh [38]	PSO based Hue Preserving color image improvement method.	This technique is used to enhance the quality of color images.	Gamut problem is witnessed in few images
39.	Saeedi and Faez[39]	MOPSO, Contourlet transform and Shift-able transform.	Impeccable and robust.	Pan and MS images has different resolution so it cannot directly combine in the spatial domain.
40.	Tan et. al. [40]	PSO is used for skin lesion segmentation.	Hybrid optimization algorithms are used for impressed stagnation.	Only uses three skin lesion databases.
41.	Dhaou et. al. [41]	3D video anaglyph watermarking	Highly invisible and robust against various attacks.	Not robust against intentional attacks like collusion.
42.	Liu et. al. [42]	Content based semi fragile algorithm	Better results for high quality compression JPEG.	Recovery of the tempered area will be studied in future.
43.	Ahmadi and Akbarizadeh[43]	Multi-layer perceptron neural network and PSO	Performance is better than the other techniques.	Need to find proper classifier to increase efficiency
44.	Huynh and Lee[44]	Discrete wavelet Transform (DWT)	SMLA watermarking produced remarkable imperceptibility.	Extraction and accuracy for lossy compression can be improved

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45.	Omran et. al. [45]	DE based clustering Algorithm	Unsupervised classification and division of medical images	Performance of gbest DE needs more investigation.
46.	Patra et. al. [46]	Alpha Blending	Due to increase of alpha the image quality is improved.	Some post processing work need to be done.
47.	Thanki [47]	RONI based visible watermarking and HVS for authentication.	This is use for medical image authentication to improve PSNR and imperceptibility when compared to many existing schemes.	Only useful for medical images.
48.	Munaga et. al. [48]	Evolutionary algorithm, Simplified threshold Accepting algorithm.	GA, STA and Evolutionary algorithm is used to increase the watermark retrieval.	Rounding issue
49.	Patil and Rindhe[49]	Non-sub tasted contourlet transform (NSCT) and DCT	3 Level NSCT and DCT is used to improve the impartibility and robustness of watermarked images.	Only useful for the medical images.
50.	Raman et. al.[50]	Visible watermarking Algorithm	High quality watermarked image.	Only tested on color images.
51.	A. J.selvakumar [51]	K-mean and fuzzy c-Mean	Combine K-Mean & C-Mean fuzzy is used to get accurate results.	Useful for 2D same procedure can be used for 3D slicer.
52.	Ewout W. Steyerberg [52]	Regression model	Bootstrapping method and Logistic regression model.	Only useful for small sample size.
53	Imran Naseem [53]	Linear Regression Classification, LRC Approach.	LRC used with Distance-based Evidence Fusion (DEF) algorithm for better results.	Not enough robust for pose variation.

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4. CONCLUSION

The paper summarizes recent state of the art algorithm for digital watermarking with in an image. From the comparative analysis of all the state of the art algorithms, it is evident that techniques for incorporating digital watermarks within an image needs to be improved. Machine algorithms can play a major part in improvising the methodology, however, there is very little literature available on the topic. There is a need to further investigate these technologies in the said domain

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