Dwt and Particle Swarm Optimization Based Digital Image Watermarking

Vikas Kumar [1], Ram Lautan [2], MHD Faisal [3], Krishna Mohan Pandey [4]
E.I.C., A.I.E.T. Lucknow, E.I.C., A.I.E.T. Lucknow, E.I.C., A.I.E.T. Lucknow, Electronics Engg.CIPL Lucknow

Abstract

This is the age of digital technology. There are amazing development has been made in the digital technology. now a day there are many work which is necessary for human used in the form of digital such as electronic publishing and advertising, transaction processing, digital image and libraries, web newspapers and magazines, network video and audio etc. These are mainly represented in digital form but due to its digital form its duplication, piracy and modification are easy. Hence to reduce these problems and increase its security various different type of watermarking is used. In this paper we proposed a secure optimized watermarking scheme for digital images, which is based on the particle swarm optimization. For embedding process we use the discrete wavelet transform for the cover image transformation and particle swarm optimization (PSO) which is based on co-relation coefficient are used to detect the high energy coefficient watermark bit in the cover image and then hide the watermark to the cover image. Then different type of attacks is employed to the watermarked image to access it robustness and imperceptibility. The performance of the scheme is evaluated by the PSNR and Correlation coefficient. The proposed scheme provides a good imperceptibility and robust for various attacks.

Keywords: discrete wavelet transform, Fitness function, watermarking, PSO, PSNR and MSE.

1. Introduction

The continuous growth of the digital technology has given us the various new possibilities, such as electronic publishing and advertising, transaction processing, digital image and libraries, digital games etc. due to its digitization, its generation, transmission, and modification is easy and fast. Now a day there are different type of technology and software is develops through which change in original image is easy and can be used by anyone illegally [1]. Due to this reason there need a strong security and integrity provider.

Digital watermarking is a type of security of the digital multimedia content. This is a famous technique which is used for copyright protection and authentication of digital image [2].

Watermarking system has mainly three distinct steps, embedding, attack, and verification or extraction (Figure1).

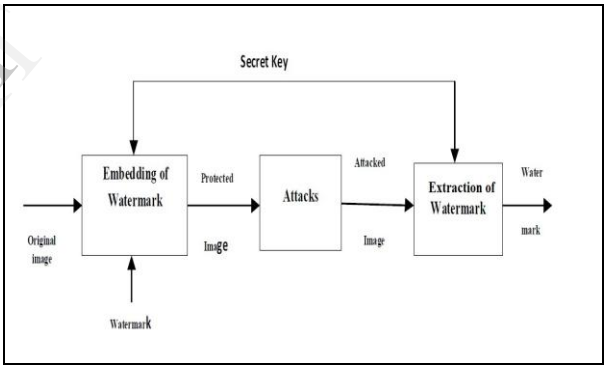

Figure 1.basic model of watermarking a image

In embedding, an algorithm accepts the host image and the watermark to be embedded, and reduces a watermarked image. Then the watermarked digital image is transmitted or stored, usually transmitted to anyone. If anyone makes a modification in it then this is called an attack. Verification (often called extraction) is an algorithm which is applied to the attacked digital image to attempt to extract the watermark from it. If the digital image was untempered during transmission, then the watermark still is present and it may be extracted. Then we say that this is the original image there have no piracy is done in it [3].

Image watermarking technique has classified in two types:

1. Spatial domain – in this type of domain significant portions of low frequency components of images should be modified in order to insert the watermark data in a reliable and robust way.

2. Transform domain - In this domain, transform coefficients are modified for embedding the watermark. Transform domain is also called frequency domain.

2. RELATED PREVIOUS WORK

Digital watermarking schemes presented in the literature are worked either in spatial domain or transform domain. I. Pitas proposed a method for generating digital watermarks on images and analyze its effectiveness. This method is based on statistical detection theory and applied in the spatial domain [4]. A.G. Bors and I. Pitas have proposed a method in which they select certain blocks in the image which is based on a Gaussian network. Thorough the DCT pixel values of the selected blocks are modified. Then any two constraints are assumed. One is embed a linear constraint among selected DCT coefficients and the second defines circular detection regions in the DCT domain [5]. C. T. Hsu and J. L. Wu have proposed a DCT based algorithm used to implement the middle band embedding. The advantage of this technique is that it can survive several kinds of image processing and JPEG lossy compression [6]. J.L. Liu, D.C. Lou, M.C. Chang and H.K. Tso have proposed a watermark scheme based on random sequence generation by seed point, in which the original watermark is transformed to one level DWT and all high frequency bands setup to zero and after take it inverse transform. Then they compared the original and transformed images [7]. Ziqiang Wang, Xia Sun and Dexian Zhang have proposed a novel blind watermark extracting scheme using the Discrete Wavelet Transform (DWT) and Particle Swarm Optimization (PSO) algorithm. The watermark is embedded using the discrete multi wavelet transform and particle swarm optimization algorithm is used for extraction [8]. E. Vahedi, C. Lucas, M. Shiva and R.A. zoroofi have proposed a new scheme based on PSO for copyright protection through a bio-inspired wavelet. The proposed scheme takes advantage of human visual system (HVS) characteristics to generate better watermarked image quality. They used visual secret sharing (VSS) technique for giving promises security of the procedure [9]. V. Aslantas, S. Ozer and S. Ozturk have proposed a novel fragile watermarking scheme based on discrete cosine transform (DCT) using particle swarm optimization (PSO) algorithm. Embedding watermarks is done in frequency domain by using the modification of the least significant bits (LSBs) of the transformation coefficients. After embedding the rounding errors generated which is correct by population based stochastic optimization technique. Simulation results show the feasibility of employing PSO for watermarking and the accuracy of this novel method [10]. Ching-Tang Hsieh, Yeh-Kuang Wu and Wei-Jen Chung have proposed multi-purpose watermarking system for halftone images with the dithering technique and particle swarm optimization (PSO) to protect the copyright. The PSO achieves good robustness and image quality. Fragile watermark is used for the attacks detected and localized. In the system, the geometric invariance method, multi-rings Zernike transform containing Co-centric rings sub-sampling and the clustering method, are adopted to estimate the angle and scaling factor accurately and achieve geometric invariance [11]. A. L. Dogan, S. Ozturk and V. Aslantas have proposed an optimal discrete wavelet transform-singular value decomposition (DWT-SVD) based image watermarking scheme using particle swarm optimizer (PSO). Firstly DWT-SVD based watermarking algorithm decomposes the cover image into sub bands, after that different scaling factor is used to modify the singular values of each sub band of the cover image to embed the watermark image. PSO is used to get the highest possible robustness without losing the transparency [12]. M. rohani and A. N. Avanaki have proposed a watermarking method in DCT domain to achieve better imperceptibility based on Swarm Optimization and the Structural Similarity Index is used in aim to have a watermarked image with the best possible quality [13]. A. Lavanya and V. Natarajan have proposed a scheme to get back the original watermark from the embedded image by Cat Swarm Optimization technique. The main advantage of it is that it has less computation time, less number of iteration and less PSO time-varying IWF for CSO method in comparison with Particle Swarm Optimization (PSO) [14]. R. V. Sivavenkateseswara, R.S. Shekhawat and V.K. Srivastava have proposed a hybrid watermarking scheme for digital images based on singular value decomposition (SVD) and particle swarm optimization (PSO). They are embedded the principal components of the watermark in the DCT domain of DWT sub band of host image. PSO is used for finding suitable scaling factors [15]. Yuh-Rau Wang, Wei-Hung Lin and Ling Yang have proposed blind watermarking method with particle swam optimization (PSO) on discrete wavelet transform. The watermark is embedded in a digital image by quantization of adjacent wavelet coefficients on wavelet trees and can be detected blindly. PSO is employ to achieve the robustness and imperceptibility [16].

In this proposed digital watermarking scheme, watermark embedded in two steps DWT using PSO. Here high energy coefficient in DWT is selected with the help of PSO and then the watermark is embedded in that coefficient. The proposed watermarking technique

are successfully experimented and checked for imperceptibility and robustness.
The rest of the paper is described as follows: - section 3 give the information about PSO and section 4 describe about proposed watermarking algorithm and section 5 provide the information about formula to be used and at last result and conclusion is presented.

3. Particle Swarm Optimization

Particle Swarm Optimization (PSO) is one of the latest techniques that have been proposed in the Computational Intelligence arena. It is persuading by the social attitude of individuals in large groups in nature. It is developed by Kennedy and Elberhart [17]. It is a population based stochastic optimization model which is generated after the social behaviour of bird flocks or fish schooling. This technique can be applied there, where a problem is given and its solution can be getting by anyway. The Particle Swarm Optimization (PSO) does not require any gradient information of the function to be optimized, uses only primitive mathematical operators and is conceptually very simple [18]. A population of individuals defines called "particles. Each particle has a position, a velocity and a memory. Value of the objective function for these individuals represents their positions.
Each particle moves free in the search space with a certain degree of freedom and randomness, looking where the objective function is better. Each particle has the capacity to dig into the past for its best position and to share its current performance with other particles of the swarm. The individual's best solution is called the particle best or the local best and the best solution among all the neighbours are called global best.
Recently there are many new change algorithm on basic PSO have been proposed as like Vrahatis and K. E.[19] given a Particle swarm optimization method for constrained optimization problems on a penalty framework.
The real particle swarm optimization method shows every particle like a potential solution of a problem in n – dimensional space. The modification in particle local best and global best can be defined as the velocity value. Velocity of each particle is upgraded by using the following equation (1) and the every particle updated its position by equation (2)

$$Vr(t+1) = D*Vr(t) + C1*rand1*(P(t) - Xr(t)) + C2*rand2*(G(t) - Xr(t)) \quad (1)$$

$$Xr(t+1) = Xr(t) + Vr(t+1) \quad (2)$$

Where:-

D	Non negative inertia factor
Vr(t)	The velocity of particle
Xr(t)	The current position of particle
C1	Determine the relative influence of the cognitive component
C2	Determine the relative influence of the social component
P(t)	pbest of particle
G(t)	gbest of the group
rand1 and rand2	Random numbers used for maintain the diversity of the population and the uniformly distributed in interval [0, 1].

Steps Used PSO Algorithm

The main steps of the PSO are given below:

Step 1 - each particle initial position and initial velocity is generated randomly.
Step 2 - the velocity of all particles is updated according to equation (1) and the position of all particles is updated according to equation (2).
Step 3 - If the fitness of the current particle is smaller than its previous best (pbest) fitness, replace pbest by the update pbest.

pbest = p(t) if f(p(t)) > pbest

Step 4 - For each particle, if its fitness is smaller than the best one (gbest) of all the particles, update gbest.

gbest = g(t) if f(g(t)) > gbest

Where, f (t) is the objective function to be optimized.
Step 5 - the process is update till the certain termination conditions are not founded. When the Process terminates the pbest and gbest is determined.

4. Proposed Watermarking Algorithm

The watermarking embedding algorithm which is used in this paper is given below:

Step 1- select an image of size M x M.

Step 2- covert the image into the 256 x 256 and used it as a cover image.

Step3- perform one level DWT on the cover image and split the image in four Sub-bands LL1, LH1, HL1, HH1. LL sub-band consists of low resolution Approximation coefficients of the host medium, LH sub-band contains the vertical Details, HL consists of horizontal details, and HH sub-band has diagonal details.

Step 4- then again perform the DWT on the LL1 sub-band and split it into 4–sub-bands. LL12, LH12, HL12, HH12. Step from 3 to 4 called 2 –LEVEL DWT.
Step 5- select the watermark image with scale 128 x 128 and apply pre-processing on it.
Step 6- apply the PSO on 2-LEVEL DWT to find the high energy coefficient in which to embed the watermark.
Step 7- perform the inverse 2- LEVEL DWT to generate the watermarked image.

The watermark extraction procedure is the just opposite of the watermark embed procedure.

5. Performance Evaluation

The algorithm of watermark embedding and extraction are performing by using MATLAB.
The performance of the method is evaluated by the MSE, PSNR and Correlation coefficient. Through the PSNR we measure the imperceptibility and the through the correlation coefficient we measure the robustness.

Imperceptibility:

$$PSNR = 10\log_{10}\left[\frac{D_M^2}{MSE}\right]$$

Where D_M is maximum possible value of the pixels in image D,

$$MSE = \sum_{a=0}^{C-1}\sum_{b=0}^{D-1}\frac{[D(a,b) - D'(a,b)]^2}{C \times D}$$

Where D, and D' original and watermarked image respectively, with size of C x D.

Correlation coefficient:

$$\rho = \left[\frac{\sum_{a=0}^{C_w-1}\sum_{b=0}^{D_w-1}[Z(a,b) \times Z'(a,b)]}{\sum_{a=0}^{C_w-1}\sum_{b=0}^{C_w-1}Z'(a,b)^2}\right]$$

Where Z and Z' are embedded and extracted watermark with size Cw x Dw.

6. Result

The proposed watermarking scheme has been experimented on various images. Here we presented only a baboon image size (256 x 256) as a cover image and a logo image LG of size (128 x 128) as a watermark image. As shown below fig 2.a and 2.b:

Figure 2.a cover image

Figure 2.b watermark logo

On proceeding technique of watermarking on it we get a watermarked image as shown in figure 2.c.

Figure 2.c watermarked image

And on extracting the cover image and watermark logo from the watermarked image we get the below image figure 2.d and figure 2.e.:

Figure 2.d extracted cover image

Figure 2.e extracted watermark logo

Obtaining the PSNR value of watermarked image we get 60.65 and correlation factor is 0.92 without attack. On introducing the salt and pepper noise the watermarked image and extracted logo image is shown in figure 3.a and 3.b.

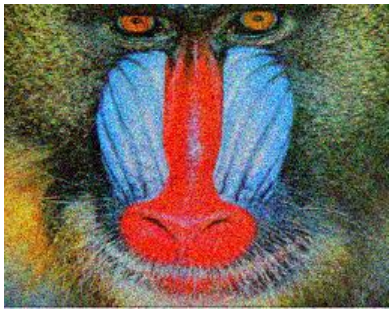

Figure 3.a salt and pepper noise image

Figure 3.b extracted logo

7. Conclusion

In this paper a robust and imperceptible watermarking scheme has been proposed which is based on the 2-Level DWT and Particle swarm optimization. Here the proposed watermarking algorithm is implemented on matlab 7.0 and experimental result shows that this technique is more robust and imperceptible than without PSO.

8. References

[1] Primo Braga, C. Fink & C. P. Sepulveda "Intellectual Property Rights and Economic Development" technical report, The World Bank, Washington D.C 2000

[2] K. Kuppusamy, K. Thamodaran "Optimized Image Watermarking Scheme Based on PSO" in procedia Engineering Int. Conf. on modeling optimization And computing (ICMOC), pp. 493-503, India-2012

[3] K. A Navas and M. Sasikumar "Survey of Medical Image Watermarking Algorithms" SETIT 2007 4rth Int. Conf. sciences of electronic, technologies of Information and Telecommunications March 25-29, 2007

[4] I. Pitas "A Method for Signature Casting on Digital Images" International Conference on Image Processing, 1996, pp. 215-218 vol.3, Lausanne

[5] A.G. Bors, I. Pitas "Image Watermarking using DCT Domain Constraints" International Conference on Image Processing, 1996, pp. 231 – 234 vol. 3, Lausanne

[6] C-T Hsu, J-L Wu "Hidden Digital Watermarks in Images" IEEE Trans. Image Processing, vol. 8, pp 58–68, January 1999.

[7] J.L. Liu, D.C. Lou, M.C. Chang, H.K. Tso "A Robust Watermarking Scheme using Self Reference Image" Computer Standards and Interfaces 28

(2006) 356–367.
[8] Ziqiang Wang, Xia Sun, Dexian Zhang "A Novel Watermarking Scheme Based on PSO Algorithm" Bio-Inspired Computational Intelligence and Applications Lecture Notes in Computer Science Volume 4688, 2007, pp. 307-314, China
[9] E. Vahedi, C. Lucas, M. Shiva and R.A. zoroofi "A New Approach for Image Watermarking by using Particle Swarm Optimization" IEEE International Conference on Signal Processing and Communications, 2007, IC SPC, pp. 1383 -1386, Dubai
[10] V. Aslantas, S. Ozer and S. Ozturk "A Novel Fragile WatermarkingBased on Particle Swarm Optimization" IEEE International Conference on Multimedia and Expo, 2008, pp. 269– 272, Hannover
[11] Ching-Tang Hsieh, Yeh-Kuang Wu, Wei-Jen Chung "Digital Watermarking System for Halftone Images Based on Particle Swarm Optimization" IEEE International Conference On Ubi-Media Computing, 2008 ,pp.201-206 , Lanzhou, Tamsui
[12] V. Aslantas, A.L.Dogan, S. Ozturk, "DWT-SVD Based Watermarking" IEEE International Conference on Multimedia and Expo, 2008, pp 241-244, Hannover
[13] M. rohani and A. N. Avanaki "A Watermarking Method Based on Optimizing SSIM Index by Using PSO in DCT Domain" International CSI Conference, 2009, pp. 418-422, Tehran
[14] A. Lavanya,V. Natarajan "Analyzing The Performance of Watermarking Based on Swarm Optimization Methods" Advances in Computing And Information Technology Advances in Intelligent Systems and Computing Volume 178, 2013, pp 167-176, India
[15] R.V.Sivavenkateseswara, R.S. Shekhawat and V.K. Srivastava "A DWT-DCT-SVD Based Digital Image Watermarking Scheme Using Particle Swarm Optimization" IEEE Students' Conference on Electrical, Electronics and Computer Science (SCEES), 2012, India
[16] Yuh-Rau Wang, Wei-Hung Lin; Ling Yang "A Blind PSO Watermarking Using Wavelet Trees Quantization" International Conference on Machine Learning and Cybernetics (ICMLC), 2011, Guilin
[17] J. Kennedy, R.Eberhart "Particle Swarm Optimization" in proceeding of the 1995 IEEE Inter. Conf. on Neural Networks, IEEE Service Centre, Piscataway, NJ, pp. 1942-1948, 1995
[18] Sagar Tiwari, Samta Gajbhiye, "Algorithm of Swarm Intelligence Using Data Clustering" International Journal of Computer Science and Information Technologies, Vol. 4 (4), pp 549 – 552, 2013 India
[19] Parsopoulos K. E. and Vrahatis M. N. "Particle Swarm Optimization Method for Constrained Optimization Problems" in Proceedings of the Euro-International Symposium on Computational Intelligence, 2002