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REVIEW ARTICLE

WATERMARKING TECHNIQUE BASED ON TRANSFORM DOMAIN FOR COPYRIGHT PROTECTION

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ABSTRACT

Watermarking is a technique to embed extra information into the content directly. Digital watermarking is embedding various information in digital content which are to be protected from illegal copying. Digital watermarking finds applications like fingerprinting, owner identification apart from the copyright protection. To embed the data into an image both SVD (Singular Value Decomposition) and DCT (Discrete Cosine Transform) have been used. In this research, a new robust watermarking scheme is proposed based on the Transform domain techniques of DCT and SVD. The DCT coefficients are mapped in a zigzag order into four quadrants after applying the DCT to original image, and SVD is applied to each quadrant. By modifying the singular value of Discrete Cosine Transformed host image then the watermark is embedded, subsequently it is modified in each area with the G quantizing value using Particle Swarm Optimization to increase the robustness and the visual quality. Watermark extraction is performed by the inversion of watermark embedding process. Experimental result is to illustrate that the proposed work able to withstand a imperceptibility as well as variety of image processing attacks.

INTRODUCTION

Digital watermarks could be used to verify the authenticity or to show the identity of its owners or integrity of the carrier signal. In response, new technology, called digital watermarking, used to protect the integrity of digital information and also to safeguard the intellectual property rights. Copying control, tampering proofing and assessments, and finger printing has become important issues. To solve these issues, watermarking is used. It is prominently used for tracing copyright infringements for banknote authentication.

The main characteristics needed for digital watermark are,

a) Imperceptibility: The watermarked image should look like as original image to human eye. The viewer couldn't detect that watermark is embedded in image.
b) Security: Unauthorized person cannot retrieve or detect or modify the embedded watermark.
c) Robustness: The watermark should be stable after normal signal processing operations such as image transformations, compression and cropping.

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Digital multimedia technologies are used in lots of applications so need to provide special importance for copyright protection to data. In the past few years, digital watermarking has received lot of attention. There are two types of watermarks, most important one is invisible, which cannot be perceived by the human eye and the other is visible, for example different logos either on a TV screen or on a paper. An invisible watermark can be either fragile or robust. The robust watermarking is used to provide proof of ownership of the multi media. Recently, it was used as one of the means of Digital Right Management. On the other hand, the fragile watermark used to verity if the protected media was tampered with or not. This type of watermark is designed to be as fragile, so the slight modification of the media data will destroy it which is indicating that someone tampered with the media in question. This type of watermark is like a CRC (cyclic redundancy code). Watermarking itself includes Discrete Cosine Transforms (DCTs), Singular Value Decomposition (SVDs), Discrete Fractional Fourier Transforms (DFFTs) and Discrete Wavelet Transforms (DWTs) can be grouped into two different approaches; spatial domain is one of the approaches and the other one is transform domain. In the former approach LSB (Least Significant Bit), watermarking is directly embedded into the pixel locations, while in the latter approach; by changing the frequency components the watermark is embedded. The watermark has to satisfy several requirements such as semi-blind, non-blind and blind schemes.

Non-blind scheme requires both the secret key(s) and the original image for watermark extraction. The semi-blind scheme requires both watermark sequences Sand secret key(s), but the blind scheme can only use the secret key(s). In this project, an efficient blind copyright protection for document images is provided through a combination of DCT-SVD based on PSO. The rest of the paper is structured as follows: Section 2 presents the related works. Section 3 explains the basic concepts of transform domain techniques and implementation steps. Section 4 describes the proposed methodology. Section 5 deals with the experimental results. Section 6 summarizes the conclusion of the research.

Related works

In previous researches, different watermarking schemes have been proposed for blind DCT-SVD watermarking. Genetic algorithm (GA) is used for optimization purpose in digital image watermarking. For example Shi-Jinn Horng *et al.* [2013] proposed a new watermarking scheme in digital images using DCT-SVD based on genetic algorithm (GA). Here, to embed the watermark image into the cover image, its singular values were modified through the multiple scaling factors. The proper values of scaling factors were efficiently obtained and optimized by means of the GA. The watermarking scheme based on the DCT (Discrete Cosine Transform) was proposed in [Yang *et al.,* 2008]. The input image was divided into blocks and then DCT was applied on each block. The low-frequency coefficients of the DCT block was selected to embed the secret information by quotient-embedding algorithm. Sawsan [Didi Rosiyadi *et al.,* 2012], furthermore, introduced a novel technique based on PSO with roulette wheel selection and Cauchy mutation. In each generation the best performed particle is identified by roulette selection. It is used to overcome the premature convergence and to reduce the tendency of trapping into local minima. The merging Cauchy operator to PSO is good in the global search and also PSO used to select the best particles and eliminate the bad ones. Didi Rosiyadi *et al.* proposed DCT to the host image, mapping the DCT coefficient in a zigzag order and then applying the SVD on the sub-block and the singular value in each sub block that was modified to embed the watermark image. The image quality was then improved with the GA-based evolution. The experiment use the peak signal to noise ratio (PSNR) to measure the watermarked image quality and correlation coefficient to verify the existence of the watermark. PSO algorithm based DCT-SVD technique mentioned in some of the researches but none of them has conducted a research using DCT-SVD technique based on PSO algorithm in the blind watermark. PSO algorithm used to optimize the value of singular factor of watermark in e-government document images. Therefore, the proposed method is going to explain a new combined blind copyright protection scheme for E-government document images in this paper.

Fundamental concepts

This paper in turn is to present the copyright protection for government document images through a combination of SVD (Singular Value Decomposition) and DCT (Discrete Cosine Transform) based on PSO algorithm. Blind watermarking scheme is used in accordance with the considerations of the excellence of the blind watermarking scheme is compared to the other schemes and it is suitable for various internet applications without any original cover to receivers.

Discrete Cosine Transform

Two-dimensional DCT technique is used in this proposed scheme. DCT is used to convert a signal to the elementary frequency components. The Discrete Cosine Transform formula is given in Eq. (1):

$$c(r,s) = \propto (r) \propto (s) \sum_{x,y=0}^{N-1} \sum f(x,y) . \cos\left[\frac{(2x+1)\pi r}{2N}\right] \cos\left[\frac{(2y+1)\pi s}{2N}\right] \quad \dots\dots\dots (1)$$

Then the inverse DCT formula is stated in Eq. (2):

$$f(x,y) = \sum_{x,y=0}^{N-1} \sum \propto (r). \propto (s). c(r,s) . \cos\left[\frac{(2x+1)\pi r}{2N}\right] \cos\left[\frac{(2y+1)\pi s}{2N}\right] \quad \dots\dots\dots (2)$$

Singular Value Decomposition

The SVD (Singular Value Decomposition) technique has been used in different applications, such as pattern analysis, signal processing and data compression. The quality of the image does not affect much by changing the SVs of the Singular Value Decomposition transformed value is applied to the cover image. The SV value is robust to the image processing attacks and does not change much after their application to the image. From the linear algebra viewpoint, the Singular Value Decomposition of any discrete image matrix B of size mxn can be represented as shown in Eq. (3):

$$A = U \Sigma V^T \quad \dots\dots\dots (3)$$

Where V and U are orthogonal matrices ($V^TV=I$, $U^TU=I$) and the size of matrices are nxn and mxm respectively. The vertical and horizontal details of an image are given by the columns of V and U matrices called as right and left singular vectors respectively. The diagonal matrix S has nonzero elements called singular values of the matrix. They are arranged in decreasing order from the first SV to the last one and represented as the luminance values of the image layers.

Particle Swarm Optimization

Kennedy and Eberhart were introduced about the Particle Swarm Optimization. Initially this technique is motivated for simulating social behavior of organism such as fish schooling or bird flocking. PSO optimization used to solve different problems. Like other evolutionary algorithms, PSO initializes with a population of randomly generated solutions called particles which fly through the search space by updating the generation. Each particle is represented by a candidate solution to the optimization problem, and has a position and a velocity.

The particles position is affected by the best particle in its neighbourhood and the best position visited by it. In the population the best particle is denoted as gbest (global best), while the current particle's best position is denoted as pbest (local best). Each particle is updated by the following equations (4) and (5):

$$v_i(n+1)=w_i v_i(n)+c_1 rand_1()(pbest-x_i(n))+c_2 rand_2()(gbest-x_i(n)) \quad ....(4)$$

$$x_i(n+1)=x_i(n)+v_i(n+1) \quad .... (5)$$

Where:

$x_i(n+1)$ and $x_i(n)$ represent the current and previous positions of particle i.
$v_i(n+1)$ and $v_i(n)$ represents the current and previous velocity of particle i.
$rand_1$ and $rand_2$ are random numbers which are uniformly distributed within [0,1].
W is an inertia weight, controls the momentum of the particle.

In typical implementation of PSO algorithm, the value of w_i is decreased linearly from 1.0 to 0 in each iteration. Commonly the inertia weight is set according to the following Eq. (6):

$$w_i=w_{max} - \frac{w_{max}-w_{min}}{iter_{max}} .iter \quad .....(6)$$

Where

max *iter* is the maximum number of iterations.
iter is the current number of iterations.

The proposed methodology

The watermarked scheme is generated by means of the following two steps.

- Watermark Embedding Process
- Watermark Extraction Process

Watermark embedding process

1. Apply the DCT to the whole host image A.
2. The zig-zag sequence is used to map the DCT coefficients into 4 quadrants: C1, C2, C3, and C4.
3. Apply SVD to each quadrant: $A_d^m = U_d^m S_d^m V_d^{mT}$, m = 1,2,3,4. where m denotes C1, C2, C3, and C4 quadrants.
4. Apply DCT technique to the whole watermark W.
5. Apply SVD to the DCT-transformed watermark W: $W = U_W S_W V_W^T$.
6. Modify the singular values in each quadrant C_m, m = 1,2,3,4, with the singular values of the DCT-transformed watermark. $X^m_d = S^m_d(1,1) \bmod G$
   where $S^m_d(1,1)$ is the singular values of DCT-transformed host image on the first element of the maximum singular value of matrix in each area.
7. The value of watermark W_d is a binary image and the process of watermark embedding involves two cases: embedding the pixel value of '1' and embedding the pixel value of '0'. When W_d=0, it will be embedded as follows:
   If $(X^m_d<3G/4)$,then $S^{rm}_d(1,1)=S^m_d(1,1)+G/4-X^m_d$ else $S^j_d(1,1)= S^m_d(1,1)+5G/4-X^m_d$.
   When W_{dct} = 1, it will be embedded as follows:
   If $(X^m_d<3G/4)$, then $S^{rm}_d(1,1)=S^m_d(1,1)-G/4+X^m_d$ else $S^m_d(1,1)= S^m_d(1,1)-5G/4+X^m_d$.
   In this Step, decides the optimal of quantizing value G using PSO Algorithm for each area.
8. Obtain the 4 sets of modified DCT coefficients
9. Map the modified DCT coefficients back to their original positions.
10. Apply the IDCT to obtain the watermarked image.

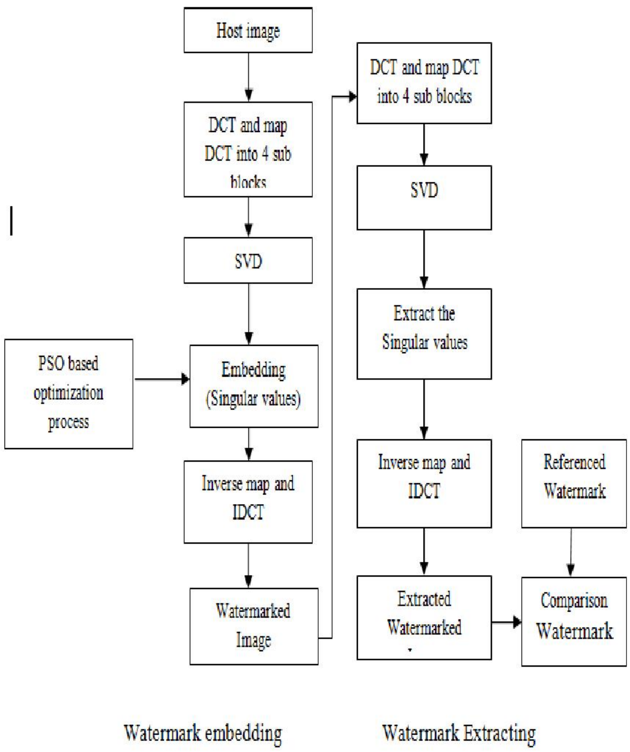

Fig. 1. Watermarking Process

In Step 6, to determine the robustness of the proposed method, the singular value of Discrete Cosine Transformed host image is modified on each area using the quantizing value (G). Here, the watermark must be resistant from various attacks. The quantizing value of G can be minimized or maximized to achieve the robustness. Based on certain attacks, the robustness of image will be changed. The value of G and the robustness is not linear in that, both of them rely on the different criteria such as image block and the type of attack complexity. A certain value of G can result in a lower level of resistance for certain block but it can also result in a higher level of resistance for other blocks. With the existence of the block condition that is less influenced and more influenced by attacks, this will also be different depending on the specification of each image. Hence, the best solution for this condition is obtaining the accurate value of G for each specification of image. In the proposed method, in order to obtain the accurate value of G, it is done by optimizing the value of G using PSO algorithm that is obtained through Step 7. In Step 8, the modified Discrete Cosine

Transformed coefficient is obtained in each area. In Step 9, coefficients of image are modified so it back to their original positions.

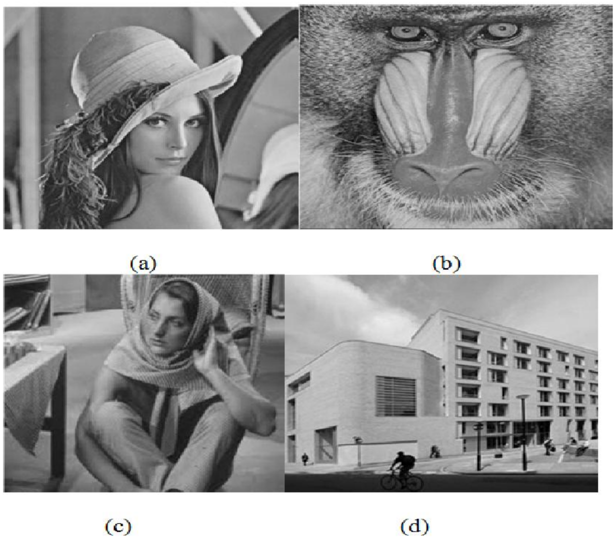

Fig 2. (a), (b), (c), (d) host images used

Fig 3. Watermark Image Used

Finally, in Step 10, inverse IDCT is applied to obtain the watermarked image. The processes of the proposed watermarking scheme is shown in Fig. 1 consists of watermark embedding and watermark extraction processes. The processes of the proposed watermarking scheme is shown in Fig. 1 consists of watermark embedding and watermark extraction processes.

Watermark Extraction process

The steps for watermark extraction process are as follows,

1. Apply the DCT to the whole watermarked image.
2. The zig-zag sequence is used to map the DCT coefficients into 4 quadrants: C1, C2, C3, and C4.
3. Apply SVD technique to each quadrant.
4. Extract the singular values from each quadrant of watermarked image.
5. Construct the DCT coefficients of the four watermarks using the singular vectors.
6. Apply the IDCT to four visual watermarks to get the extracted image.

Experimental results

The performance of the proposed methodology is simulated using MATLAB10. The proposed methodology is tested for various host images of size 512X512 and watermarks of size 64X64 as shown in Fig. 2 and Fig. 3 respectively. To measure the quality of the watermarked image, the peak signal to noise ratio (PSNR) criteria is used as defined in Eq. (7). To measure the objective function values, the minimum square error (MSE) is used as defined in Eq. (8):

$$PSNR=10.\log_{10}(255^2/MSE) \quad \text{…. (7)}$$

$$MSE=\frac{1}{MN\sum^{M}_{x=1}\sum^{N}_{y=1}(A(x,y)-A'(x,y))^2} \quad \text{….(8)}$$

Table 1. Estimation of PSNR and MSE value using for PSO and GA technique.

Images		PSO(Proposed Methodology)	GA(Existing Methodology)
Lena	PSNR	51.9748	45.7388
	MSE	0.0164	0.0336
Bafoon	PSNR	67.0585	52.6875
	MSE	0.0029	0.0151
Girl	PSNR	70.3798	57.6819
	MSE	0.0020	0.0085
Building	PSNR	69.7936	45.3904
	MSE	0.0021	0.0350

Table 2. Experimental results of PSNR values under various attacks.

Images		Proposed Methodology(PSO) PSNR Values	Existing Methodology(GA) PSNR Values
Gaussian Noise	Bafoon	31.1805	31.1712
	Lena	31.1409	31.0024
Poisson Noise	Bafoon	31.2490	31.0851
	Lena	31.1497	31.1408
Salt and Pepper Noise	Bafoon	35.467	32.3104
	Lena	31.1347	30.6599

where both I(x,y) and J(x,y) denotes the values of the original and the watermarked images and its size is M*N. A large number of experiments have been done with the above mentioned host images and watermark images to test the efficiency of the proposed method. The quality of the watermarked image from the original image is measured with the Peak-Signal-to-Noise-Ratio (PSNR) value. It is highly achievable value in the experiments performed signifies the good indistinguishability of the watermarked image from the host image. The strength of the algorithm varies and its variation in the PSNR value is shown in Fig. 4.

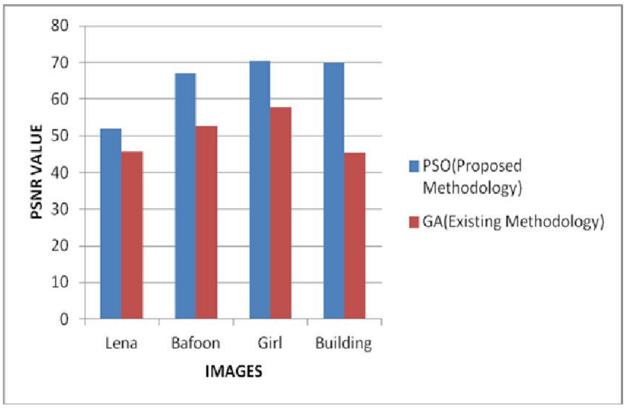

Fig 4. Comparison of proposed method with existing method based on PSNR

Conclusion

The DCT-SVD technique based on PSO optimization scheme used in the watermarking for copyright protection performs better than the DCT-SVD based on GA optimization scheme. DCT-SVD watermarking scheme is considered for four areas of the host image and the security level is enhanced by scrambling in the specific zig-zag manner. The error difference is also comparatively low for DCT-SVD based on PSO scheme with the existing techniques. The future work can be focused to make the proposed method is applicable to the video watermarking and further enhancing its robustness against variety of attacks.

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