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Harmony Search based Watermarking Scheme for Images

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Abstract This paper describes image watermarking scheme that efficiently uses Harmony Search Algorithm (HSA) for robustness and imperceptibility parameter. An image which is embedded in the cover image is a binary image. To perform the embedding operation the cover image need to be converted into frequency domain. The pixel locations used for watermark embedding are identified by HAS which make use of a linear function as fitness function. This function is formed by summing up the four different values of similarity parameter obtained by applying the four different image processing operations. The results obtained after embedding and extraction of watermark proves that this scheme generate high values of psnr parameter, which shows that the visual quality is good. Also the robustness parameter shows good result. So, it can be said that this scheme list better and improved results than other schemes.

1 INTRODUCTION

Digital media is used now days everywhere, so there is a need to check the copyright violations caused in these media. [9-11]. Form last many years different strategies have been developed to protect this violation. Watermarking schemes emerged as one of the main tool for this. Watermarking schemes need to establish the balance between two major criteria: visual quality and robustness against attack. As it is difficult to find the balance between these two parameters as these two are inversely proportional to each other. To optimize this balance various optimization algorithms are used. In today's scenario soft computing techniques are used as an optimization tool for various applications. Worldwide many researchers worked in this direction and found that the soft computing can successfully optimize the parameters of watermarking schemes.

Chin Shiehet. al.[1] have used soft computing technique such as genetic algorithm (GA) for this purpose. They have used genetic algorithm to optimize this tradeoff. To optimize watermarking scheme they have used a fitness function which is shown by Eqn. 1.

$$f_c = PSNR_c + \sum_{h=1}^{p}\left(NC_{c,h}.\lambda_{c,h}\right) \qquad (1)$$

These authors claim that their selected fitness function for genetic algorithm successfully balance the tradeoff between the parameters of watermarking application and obtained good results.

Another researcher Zhicheng Wei et. al. [2] have also make use of genetic algorithm to optimize this tradeoff but in a different way. They have used GA to find the locations or coefficients value in an image on which embedding can be done.To optimize image watermarking scheme they have used a fitness function which is shown by Eqn. 2.

$$Fitness = \sum_{i=1}^{4} Sim_i \qquad (2)$$

Authors of this paper obtained good visual quality of the signed image and also their proposed scheme can survive against many image operations.

Another researcher Huang et. al [3] have used another soft computing technique known as fuzzy theory with bacterial foraging for image watermarking application. To optimize their watermarking scheme they have used a fitness function which is shown by Eqn. 3.

$$\mathrm{f_i} = \mathrm{PSNR_i} + \lambda.\mathrm{BCR_i} \qquad (3)$$

These authors make use of PSNR and BCR in their fitness function. They also obtained better and improved results than other watermarking schemes.

Also evolutionary algorithms can be used for this application. In this paper we are using recently developed algorithm Harmony Search Algorithm proposed by Geem et al. [12-14] for optimizing the watermarking application. This scheme makes use of the fitness function defined as Eqn. (2). Harmony search algorithm is based on music harmony. This algorithm is used for watermarking of grayscale images. The present paper list the embedding and extraction algorithm. The issue of image visual quality and robustness against several attacks discussed here. The attacks performed in this paper are – with radius 0.1 performing low pass filtering, scaling operation from 256 to 512 and again 256, adding Gaussian noise and with Q=5 performing JPEG compression. Similarity correlation coefficient parameter is used to compute the robustness parameter in current simulation.

2 HARMONY SEARCH ALGORITHM

HSA proposed by Geem et al. [12-14] is an optimization technique which was already used in many applications Its main concept is based on the concept music that musician always wants to achieve an ideal state of harmony in their music which can be compared with the improvement in the solution of optimization problem.

To improve the harmony in music, a trained musician can make a choice from following options:

(1) Musician can select any piece of music from his or her memory for playing the music;

(2) Musician can select any music similar to a known piece; or

(3) Musician can compose a fresh music or notes.

Z. W. Geem et al. [12] used these three choices as three elements of the algorithm:- it makes use of harmony memory, it also adjust the pitch, and perform the organization. Algorithm for HSA is listed in Listing 1.

Listing 1:

Input: Define the input set as follows:

1. *Define the objective function*
   f(y), =[y_1,y_2,…………..,y_m]^T
2. *Generate initial harmonics y_p (p=1,2,…,n)*
3. *Define pitch adjusting rate (rand_pa), pitch limits and bandwidth*
4. *Define harmony memory accepting rate (rand_accept), maximum number of iterations (ML)*

Output:

The output produced is written as :
The best solution y_i^{max} with the largest objective function value

```
Begin
while (t < ML)
Generate new harmonics by accepting best harmonics
Adjust pitch to get new harmonics (solutions)
if (rand> rand_accept)
choose an existing harmonic randomly
else if (rand>rand_pa)
        adjust the pitch randomly within limits
else
generate new harmonics using randomization
end if
Accept the new harmonics (solutions) if better
end while
Find the current best solutions
End
```

3 Proposed Scheme

In this scheme, a binary image picture of the size p x q is utilized to implant into the host picture. The optimization methods used for this reason generally o perate on either of the two approaches- optimizing the implanting process [7-9] or defining the coefficients to be chosen for implanting, accompanied by actual embedding by using a standardized formulation[1-3].As referenced before, we propose an implanting and extraction watermark scheme that comprises the HSA. In our case, we use it to recognize upgraded areas for inserting the coefficients of the cover image utilized as unique watermark (W). The fitness function utilized in this is same as defined in Eqn. 2. This is a direct summation of four comparability connection esteems SIM. Relationship parameter are processed between the installed one piece picture (W) and separated one piece picture (W'). Here, W' is the separated watermark which is recuperated from four unique pictures acquired by executing four distinct operations over marked pictures. The similarity relationship is processed by utilizing the definition in Eqn. 4.

$$SIM(W,W') = \frac{\sum_{i=1}^{p}\sum_{j=1}^{q}[W(i,j).W'(i,j)]}{\sum_{i=1}^{p}\sum_{j=1}^{q}\sqrt{W'.W'}} \qquad (4)$$

3.1 Watermark Embedding

In our scheme, we used an image X with M rows and N columns and a binary-watermark W size (p x q) for embedding. The algorithm used to implant the binary watermark is described in follows:

Step1:

Decompose the given X image into 8 x 8 blocks in dimens ion. Using discrete cosine transformation turn any block in to a frequency domain.Just apply Harmony search algorith m to coefficients 1 through 63. The 0thcoefficient in the ser ies is omitted as DC coefficient

Step 2: Find the locations using HAS and follow these steps:

(a) Produce m Harmony's arbitrarily as the underlying populace, where every Harmony is a vector of size s. Here, s is a vector of size (p x q) that speaks to the watermark implanting areas in the host picture. At that point, from every 8 x 8 square, just a single area is chosen for inserting.
(b) Insert the watermark bits (1or 0) using Eqn. 5 at areas chose by Harmony search algorithm
(c) Find IDCT of the signed image to get signed image in spatial space. Get m such signed image independently
(d) Apply four different operations on each signed image each in turn. The attacks are– with radius 0.1 performing low pass filtering, scaling operation from 256 to 512 and again 256, adding Gaussian noise and with Q =5 performing JPEG compression.
(e) Utilize these four attacked images each in turn and in this manner we can do separate the watermarks (W's). Look at W and W^' utilizing SIM(W,W') for every one of the four attacked images for m Harmony's.
(f) Calculate fitness of m Harmony's using Eqn. 2
(g)Move these m Harmonies according to scheme mention ed in Listing 1.

Step 3: Choose signed image with the highest fitness value

Eqn. 5 describes the formula utilized in the present work for embedding the binary watermark into the host image

$$V' = V * (1 + k * W) \qquad (5)$$

Where V denotes the coefficient of discrete cosine transformation of the image given by the HSA, W is the one bit image, k is the intensity of the watermark and V' is the discrete coefficient of transformation of the watermarked image. Having performed several simulations, the value of k is taken as 0.4 in the present work. PSNR can be used to calculate perceptual quality of the watermarked images.

3.2 Watermark Extraction

The calculation used to recuperate inserted watermark from the watermarked image is given as follows:

Step 1: In original image and watermarked image, find the block wise DCT

Step 2: Watermark image coefficient values can be recovered by using Eqn. 6

$$W' = ((V'/V) - 1)/k \qquad (6)$$

Step 3: Generate or recover the watermark

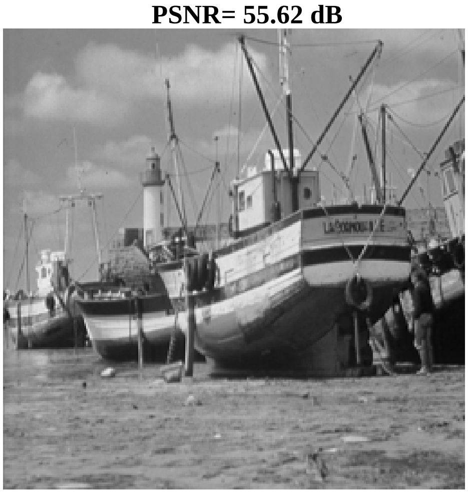
Step 4: Compare W with W' using SIM (W,W')

4 Experimental Results

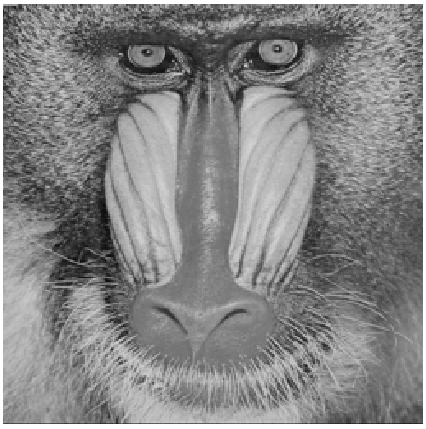
In this simulation, greyscale images were used as cover image or host image and a binary image is used as watermark. The discussed algorithm was executed on four different cover images of size 256 x 256, in which each pixel value needs 8 bit for storage. These images are standard images such as Boat.bmp, Baboon.bmp, Lena.bmp and Pepper.bmp. These images were used for performing the embedding operation. The binary image which was used as watermark is of size 32 x 32. In the execution of the proposed algorithm the following parameters were used HMCR, PAR, HMS, number of initial harmonics (n) and maximum iterations with the values 0.9, 0.1, 10, 10 and 10 respectively. The attacks performed in this paper are – with radius 0.1 performing low pass filtering, scaling operation from 256 to 512 and again 256, adding Gaussian noise and with Q =5 performing JPEG compression.Table 1 extracts the PSNR and SIM values for all the four images and also gives a comparison between the obtained results and other similar work. The original and signed images can be depicted by Fig.1. The original and extracted watermark can be depicted by Fig.2.

(a)

PSNR= 55.62 dB

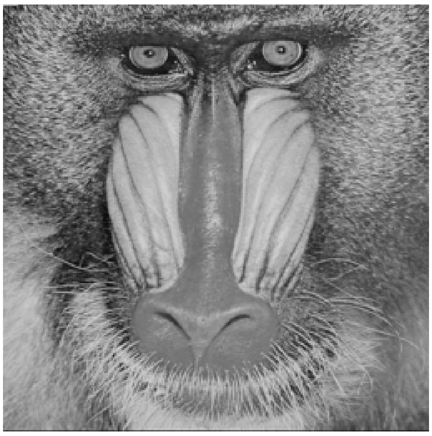


(b)



(c)

PSNR= 54.28 dB



(d)

(e)

PSNR= 54.71 dB

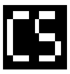
(f)

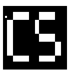
(g) 

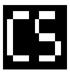
PSNR= 56.21 dB

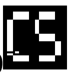
(h)

Fig.1: Cover image (a) Boat, (c) Baboon, (e) Lena, (g) Pepper, image after embedding (b) Boat, (d) Baboon, (e) Lena and (h) Pepper

(a) 

(b)  $\boldsymbol{SIM(W,W')}$ **=14.21**

(c)  $\boldsymbol{SIM(W,W')}$**=14.52**

(d)  $\boldsymbol{SIM(W,W')}$ **=14.41**

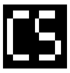
(e)  $\boldsymbol{SIM(W,W')}$ **=14.78**

Fig.2: (a) Original watermark, Recovered watermark (b) from Fig. 1(b), (c) from Fig. 1(d), (d) from Fig. 1(f), (e) from Fig. 1(h)

Table 1 list the values of similarity correlation parameter and psnr value for the four different cover images and attacked images obtained after performing the image operations. This table also give a comparison between obtained values of this simulation and the values obtained by Zhicheng Wei et. al. [2]. The tabulated values shows that the values obtained in current simulation are much higher than the other work. The implanting and extraction are quite successful as indicated by high SIM values and perceptual parameter values. This is specifically true for all four images we use in our simulation and for all attacks barring the low pass filter attack.

Table1: Comparison of PSNR and $SIM(W,W')$between our algorithm and one proposed by Zhicheng Wei et. al. [2]

Image	**Scheme**	**PSNR**	**SIM1**	**SIM2**	**SIM3**	**SIM4**
Boat	Our Work Ref. [2]	55.62 51.68	6.814 8.588	8.912 7.626	11.161 6.672	10.54 7.241
Baboon	Our Work Ref. [2]	54.28 51.87	6.761 7.121	8.552 7.161	11.990 6.192	11.92 8.565
Lena	Our Work Ref. [2]	54.71 51.55	7.871 7.579	7.923 7.289	11.561 7.715	9.281 8.247
Pepper	Our Work Ref. [2]	56.21 51.86	7.210 7.936	7.241 7.158	10.923 7.726	10.66 7.403

5 CONCLUSION

An optimized image watermarking scheme is proposed in this paper. The implanting and extraction algorithm used for executing current simulation is also listed which make use of an optimization tool known as HSA. To perform the embedding operation the cover image need to be converted into frequency domain. The pixel locations used for watermark embedding are identified by HSA which make use of a linear function as fitness function. This function is formed by summing up the four different values of similarity parameter obtained by applying the four different image processing operations. The results obtained after embedding and extraction of watermark proves that our proposed scheme generate high values of PSNR parameter, which shows that the visual quality is good.

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