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Optimal Scaling for Digital Image Watermarking

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Abstract. Humans can easily access or distribute any multimedia data from networks. So, Multimedia security is very important to deal with digital data. Thus, security has become one of the most significant problems for distributing new information. There are number of techniques for hiding the information in the form of digital contents like image, text, audio and video. Digital Image Watermarking is one of them. It is a method of embedding some secret information and important information in the input image (host image) which can later be extracted or detected for various purposes like authentication, owner identification, content, copyright protection, etc. In this paper we work on optimal scaling and PSNR value. In optimal scaling we use Differential Evolution that provides the best solution as PSNR value. High PSNR provides good quality image.

Keywords- Discrete Wavelet Transform (DWT), Singular Vector Decomposition (SVD), Optimal Scaling, Peak Signal Noise Ratio(PSNR), Sub bands.

I. INTRODUCTION

Digital Watermarking is used as an information hiding. Simply, In digital watermarking there is an input image(host image) and an watermark image. There are two processes occur in digital watermarking i.e. Embedding process and Extracting Process. When Watermark image embed on the cover image for providing security to cover image than this process is known as Embedding Process and then watermarked image is transmit over the communication channel. In this stage, when the data is transmitted over the network, some noise is added on the watermarked image or some attacks are performed on the watermarked image. So, our watermarked data is either modified or destroyed. The Embedded Watermarked is recovered in Extracted Process. Digital Watermarking has two domains, spatial domain and transform domain(frequency domain). In spatial domain method, the watermark bits are embedded directly into the pixels of cover image[4]. In transform domain, the watermark is embedded by changing the coefficient magnitude in a transform domain using Discrete Wavelet Transform(DWT), Discrete Cosine Transform(DCT), Singular Vector Decomposition(SVD)

Process of Robustness and optimization that are explained in this paper are:

1. First of all an input image and an watermark image is chosen. We apply DWT on the cover image. DWT divides image into four sub bands i.e. LL (Low Low), HL (High Low),LH (Low High),HH (High High) and then LL sub band is again split into sub bands i.e. LL2, HL2, LH2, HH2 known as 2-DWT. After that, apply SVD to smallest LL2 sub band that split the image into u, s, v matrix form and find out scaling factor of the cover image. Like this, Again apply DWT and SVD on the watermark image.

2 The Selection of fitness function is based on to the optimize Robustness. PSNR value also has major role in this paper. Higher the PSNR value provides good quality image.

II. RELATED WORK

Divjot Kaur Thind, Sonika Jinadal[1],In this paper a new watermarking is used which combines DCT(Discrete Cosine Transform), DWT(Discrete Wavelet Transform), SVD(Singular Value Decomposition) in which watermarking is performed on high frequency band and then various attacks have been applied.

Madhuri Rajawat , D S Tomar[2],This paper presents techniques, applications, classifications, attacks and tampering detection in watermarking. This paper improves the security of image by combining new algorithm for digital watermarking and tampering detection. Authors worked on RGB components for enhancing security and robustness.

Aparna J R, Sonal Ayyappan[3], It proposes a block based image watermarking algorithm in which cryptographic algorithm are used to tell about the positions of the cover(original) image in which the watermark is to be embedded.

Two different keys are generated using Diffie Hellman Key Exchange algorithm and using these keys the positions of cover(original) image to which the watermark bits are to be embedded.

Preeti Parashar, Rajeev Kumar Singh[4], The authors have given an survey of existing digital image watermarking techniques. The results of various techniques have been compared on the basis of outputs.

Lalit Kumar Saini, Vishal Shrivastava[5],This paper includes the following sections like overview of watermarking, Types of watermarking, Classification and applications of image watermarking and threats and performance evaluation in image watermarking.

Ms.Mahejabi Khan, Mr. Ajay Kushwaha, Mr. Toran Verma[6],introduced a secure and robust watermarking algorithm based on the combination of image interlacing, DWT & DCT techniques

Urvi H. Panchal, Rohit Srivastava[7],This paper provides comprehensive survey on various digital image watermarking techniques in different domains and their requirements. The author introduced the survey and classified the different requirements, benefits and limitations.

D. Vaishanavi, T.S Subashini[8], In this paper, two methods for invisible and robust image watermarking are used in RGB color space. In the first method watermark of gray scale is embedded , on the blue color channel elements and in second method, the channel of blue color element of watermark are embedded on blue color channel elements of the input(cover) image.

III. BACKGROUND REVIEW AND PROPOSED WORK

A. *Discrete Wavelet Transform*:

Discrete Wavelet transform (DWT) is an mathematical tool for decomposing an image. The transform is based on waves, and these waves are small called wavelets, of frequency that are varying and limited duration. The DWT divides the input image into four sub-bands LL (Low-Low), LH (Low-High), HL (High-Low) and HH(High-High). The LL (Low-Low) sub band represents the coarse-scale coefficients of DWT while the LH, HL and HH sub bands represent the fine scale coefficients of DWT. For next coarser scale of wavelet coefficients, the LL sub band are further processed until the size of cover image and watermark image will same. LL sub band are divided into LL2, LH2, HL2 and HH2 bands. In which LH2, HL2, and HH2 contains the highest frequency band while LL2 contains the low frequency band.

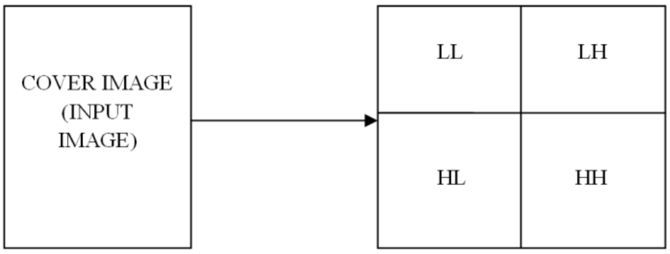

Fig 1: 1- Level DWT Decomposition

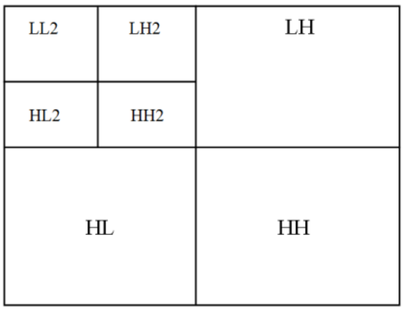

Fig 2: 2-Level DWT Decomposition

B. *Singular Vector Decomposition(SVD):*

SVD is an linear algebra technique and used to solve mathematical problems. SVD approach used in watermarking because of the fact that singular values obtained after the decomposition of image matrix are stable. The SVD belongs to orthogonal transform which decompose the matrix into three matrices of same size. In this paper we apply SVD to last LL band of input image that decompose the input image into I_u, I_s and I_v matrix form. Like this apply svd to the lowest LL band of watermark image that decompose the image into W_u, W_s and W_v. Through all this our main focus are on scaling matrix that are used to control the strength of watermarked image.

C. *Quality Measures:*

Some of quality measures used in image watermarking are:

1) *Normalized Correlation(NC):*

It tells about the comparison between original(input) image and extracted image.NC targeted to 1.0.

$$NC= \frac{\sum_{i=1}^{m} Wi*\sum_{j}^{n} Wj}{\sqrt{\sum_{i=1}^{m} Wi^2*\sum_{j=1}^{n} Wj^2}}$$

Wi= Original Watermark, Wj=Extracted Watermark

2) *Mean Square Error(MSE):* MSE in watermarking is to measures the average of square of errors between original image and watermark image.

$$MSE= 1\div MN\sum_{i}^{M}\sum_{j}^{N}(Wij - Hij)^2$$

Where M, N is pixel values in host image

Wij = Pixel value of Watermarked Image

Hij = Pixel value of Original Image

3) Peak Signal to Noise Ratio(PSNR):PSNR determines the Efficiency of Watermarking with respect to the noise.

It is given by:

PSNR=10*log(P^2/MSE)
Where p= maximum value in original image.

D. Embedding Process:

- Read both input image and watermark image.
- Use 1-level DWT to decompose the input image into four sub-bands (i.e. LL, LH, HL, HH).
- Use 2-level DWT haar to again split LL into four sub-bands (i.e. LL2, LH2, HL2, HH2).
- Apply SVD to LL2 sub band that split the image into I_u, I_ s and I_ v matrix form that extract the singular values.
  Where s = scaling matrix.
  [I_u,I_s,I_v] = svd(LL2)
- Apply DWT to the watermark image to decompose the watermark image into four sub bands
- Apply SVD to LL sub band to extract singular values
  [W_u,W_s,W_v] = svd(WLL)
- Apply optimal scale matrix, that gives best values and stores in alpha variable.
  alpha = get_optimal_scale_matrix(scaleMatrixDim);
- For watermarked image use this formula:
  S_n = I_s + (alpha.*W_s);
  new_LL = I_u*S_n*I_v';
- Apply inverse DWT to get the watermarked image.
  iLL2 = idwt2(new_LL,LH2,HL2,HH2,'haar');
  watermarked = idwt2(iLL2,LH,HL,HH,'haar');
- Calculate the PSNR value for input host image and watermarked image using formula[3].

E. Extraction Process:

- Apply 2 level haar DWT to decompose the watermarked image into four sub bands.
- Apply SVD to WMLL2 sub band to extract the singular values.
  [Wm_u,Wm_s,Wm_v] = svd(WMLL2)
- Apply 2 level haar DWT on input image to decompose image into four sub bands(i.e, LL2, LH2, HL2, HH2)
- Apply SVD to LL2 sub band .
  [I_u,I_s,I_v]=svd(LL2);
- Compute Sw, where sw is the singular matrix of extracted image.
  S_w= (Wm_s-I_s)./alpha;
- Apply haar DWT on watermark image to decompose the watermark image into sub bands(i.e, WLL,WLH,WHL,WHH)
- Apply SVD to WLL sub band to extract the singular values.
  [W_u,W_s,W_v] = svd(WLL)
- Calculate new extracted watermark by using this formula:
  new_WLL=W_u*S_w*W_v'
- Apply inverse DWT to get the extracted watermark image.
  EWatermark_img=idwt2(new_WLL,WLH,WHL,WHH,'haar');
  EWatermark_img=uint8(EWatermark_img);
- Check out the correlation coefficient of watermarked image and extracted watermark image that will be noiseless.

F. Optimal Scaling:

Optimal Scaling helps for providing the best values.
In Optimal Scaling, we used two main factors:

1) Differential Evolution(DE):

DE algorithm worked on a population of candidate solutions(called agents). These candidate solutions are moved around in the search space and creating new candidate solution by combining the existing ones according to its simple formula and if the new position of an agent is an improvement than it is accepted otherwise the new position is discarded.
Pseudocode of DE are[10] :
Formally, let f : $R^n \rightarrow$ R be the cost function which must be minimized or fitness function which must be maximized.
Let x $\in R^n$ designate a candidate solution (agent) in population. The basic DE algorithm can then be described as follows:

- Initialize all x as agents with random positions in search-space.
- Until a termination condition is met (e.g. number of iterations performed, or an adequate fitness reached), repeat the following:
  - For each agent x in the population do:
    - Pick three agents u, v and w from the population at random, they must be distinct from each other as well as from agent x

- Pick an random index R $\epsilon\{1, \dots \dots n\}$ (where,n being the dimensionality of the problem to be optimized).
- Compute the agent's new position y=[y1,……yn] as follows:
    - For each i, pick an number that are uniformly distributed $r \equiv U(0,1)$
    - If r i < CR(crossover probabiltity) or i=R then set yi=$\alpha i + F *$(v-z)
    - otherwise set yi=xi
    - (In essence, the new position is outcome of binary crossover of agent x with intermediate agent z=u+F*(v-w).)
- If f(y) < f(x) then replace that agent in the population with the improved candidate solution, that is, replace x agent with y agent in the population.

- Pick the agent from the population that has the highest fitness value or lowest the cost value and return it as the best candidate solution.

In which, F∈ [0,2] is the differential weight and CR∈ [0,1] is the crossover probability,and the population size NP>= 4. The choice of F, CR and NP parameters of DE can have a large impact on the optimization performance.

1) Fitness Function :

In this paper, we used PSNR values as fitness function. Computing PSNR function based on scaling factor of the resultant watermarked images from the techniques DWT and SVD for the purpose of measuring the distinctive distortion between the input image and the watermarked image[9]. The value of PSNR been taken to represent fidelity of watermarked image, the fitness function increases with the increase in the value of PSNR(Peak Signal to Noise Ratio). So, optimization of the fidelity takes place for the given value of robustness. As quantitative measure of the degradation effect caused by various attacks we use Peak-Signal-to-Noise Ratio. High PSNR indicates the lower value of degradation hence indicates that the watermarking technique is very much robust against number of attacks. It improves the quality of an image.

IV. RESULTS AND GRAPHS

- First of all, The watermark Embedding and Extraction process has been shown in figure (3) & figure(4), Algorithms for Watermark Embedding use man input (128×128) Image and watermark Image of size (64×64). The Scaling Factor (α) is 0.025. Figure 3 shows the embedding process. Whereas, Figure 4 shows the extraction process.

Fig 3: Embedding Process

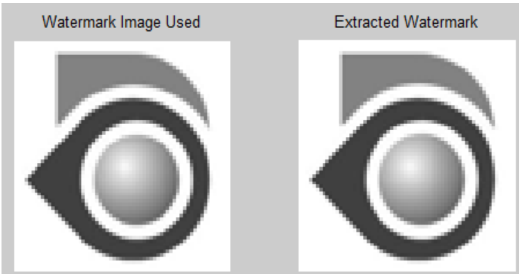

Fig 4: Extraction Process

- In second test, we take lena as input image of size (256*256) and watermark image of size (128*128). Its Embedding and Extraction process are shows in Fig. 5 and 6. Figure 5 shows the Embedding process of input image and watermark image. Whereas, Figure 6 shows the Extraction process of watermark image.

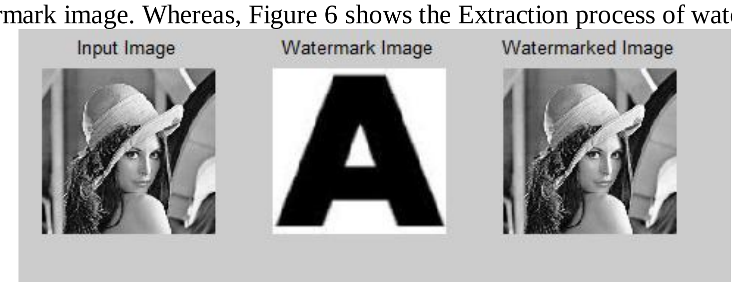

Figure 5: Embedding process

Figure 6: Extraction Process

GRAPHS:

In Fig. 7 and Fig. 8, the plotted graph is between fitness(PSNR) value and iteration. In which iteration is on the x-axis whereas, fitness value on the y-axis. Main concept of this paper is the fitness function and Optimal Scaling. Optimization algorithm that has a fitness or objective function which should always be maximized to get larger PSNR (dB) values. The value of PSNR been taken to represent fidelity of the watermarked image, the fitness increases with the increase in the value of PSNR. So, optimization of fidelity takes place for a given value of robustness. More PSNR value gives less distortion. Optimal Scaling use DE algorithm.DE algorithm worked on the population of candidate solutions (called agents). These candidate solutions are moved around in the search space and creating new candidate solution by combining the existing ones according to its simple formula and if the new position of an agent is an improvement than it is accepted otherwise the new position is discarded. Figure 7 and Figure 8 provides the best values for both cases(i.e, man and lena).These values are vary due to optimal scaling. In both figures we use iteration is of size 50

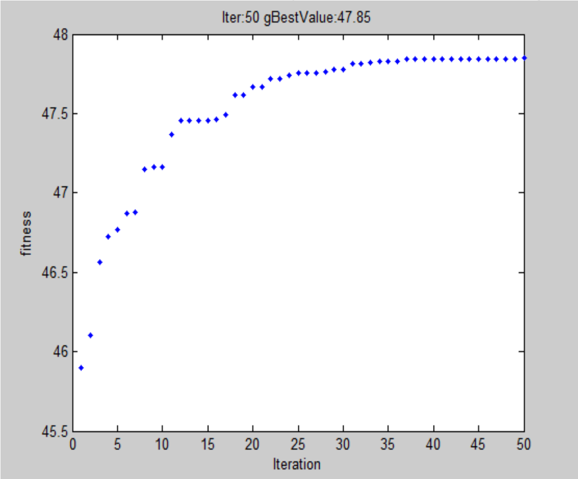

Figure 7: PSNR in case of man

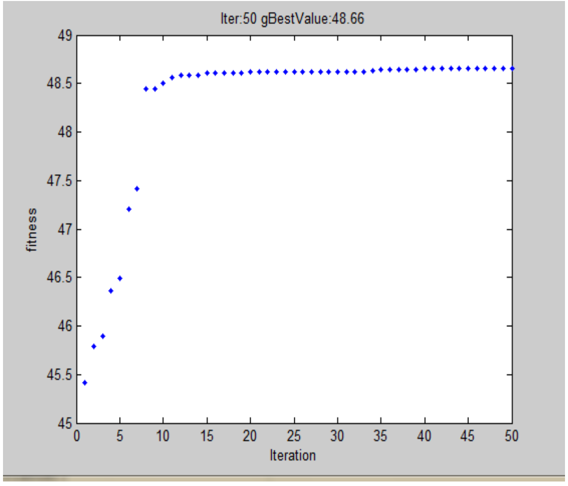

Figure 8: PSNR in case of lena

Table 1 presents the results of Figure 7 and Figure 8 . Table 1 demonstrates the optimized PSNR values when man and lena images are used as input images. Figure 9 tells about the PSNR Comparison on both approches.

Table 1: Man and Lena images on Existing approach and Proposed Approach

	Approach	Man	Lena
static-scale	**Existing**	39.898507	41.201
optimal scale	**Proposed**	47.854112	48.66488

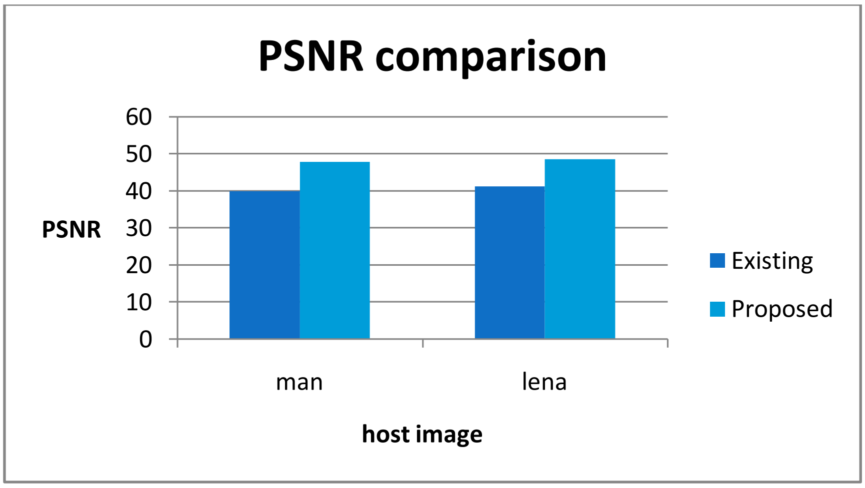

Figure 9: PSNR Comparison On Both Approaches

V. CONCLUSION

In this work, we gave the brief discussion of optimal scaling and fitness function(PSNR). Existing approach work on static-scale whereas, Proposed approach use optimal scale. So, we conclude that we increase the PSNR value in both cases i.e, man and lena images. We increase the PSNR upto 20% from existing approach to proposed approach. In Optimal Scale, the value varies all the time and also gave approximate 20% good result from existing to proposed work.

VI. FUTURE SCOPE

In Future, we would also use the concept of principle component(pc) that improve the robustness and quality of image. In our research, we used PSNR as fitness function for the efficiency of image. But in future we would also use NC(Normalized Correlation) and Hybridation(PSNR+ NC both).

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