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DE Based Optimal Scaling for Robust Image Watermarking

Gagandeep Gumber[1], Vikram Deep Aulakh[2]

M.Tech Student, Dept. of CSE, GGGI, Saha, Ambala, Haryana, India[1]

Assistant professor, Dept. of CSE, GGGI, Saha, Ambala, Haryana, India[2]

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 NC and PSNR value. In optimal scaling we use Differential Evolution that provides the best solution as NC and PSNR value. High PSNR provides good quality image. Improved NC improves robustness of image.

KEYWORDS: Digital Watermarking, Copyright Protection, Discrete Wavelet Transform (DWT), Singular Vector Decomposition(SVD), Optimal Scaling, Security, Authentication, Peak Signal to Noise Ratio(PSNR), Normalised Correlation(NC), Diffrential Evolution(DE).

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), 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. NC and PSNR value also has major role in this paper. Higher the PSNR value provides good quality image. Improved NC improves robustness of image.

II. RELATED WORK

Madhuri Rajawat, D S Tomar [1]: This paper presents digital watermarking for their applications, techniques, attacks, classifications and tempering detection. With the help of these techniques they improve the security of image. This paper worked on RGB components such as red, green, blue for enhancing robustness and security. 2-DWT applied

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on RGB components for good results. The author concluded that tampering detection and watermarking method is very important for protection against attacks.

Arash Saboori, S. Abolfazl Hosseini[2]: In this paper a new method is proposed using the combination of DCT and PCA transform in order to reduce the low frequency band for the color image in YUV color space. The Y (luminance) is divided into non-overlapping blocks and the low band coefficients of each block are placed in the matrix data than PCA transform are applied on it. This method eliminates the disadvantage of low band based on the combination of DCT and PCA transform.

Aparna J R, Sonal Ayyappan [3]: Introduced a block based image watermarking algorithm which uses the cryptographic algorithm to find out the position of the cover image in which watermark is to be embedded. The two different keys are generated using Diffie Hellman Key Exchange Algorithm and using these keys the position of cover image to which the watermark are to be embedded are found out. The embedding is done after block dividing the cover image and watermark image.The experimental results show that the proposed method is robust.

Palak Patel, Yash Patel[4]: In this paper authors have combined the strategy of Steganography, Digital watermarking and cryptography using DCT,DWT and SVD algorithm which provide security of images as a well as authenticity of the image. DWT transformed 2-D image into four sub bands i.e. Low Low(LL),High Low(HL),Low High(LH),High High(HH). The LL sub band again split into these four sub bands and this process are known as 2DWT. Authors enhanced their research by encrypting image data using RSA algorithm.

Divjot Kaur Thind, Sonika Jindal[5]: In this paper a latest digital video watermarking scheme is proposed which combines Discrete Wavelet Transform(DWT) and Singular Value Decomposition(SVD) in which watermarking is done in the high frequency sub band and then various types of attacks have been applied. The watermark object has been embedded in each frame of the original video. Since in each frame, watermark is embedded and it provides robustness against attacks.

Shankar Thawkar [8]: This paper presents an invisible image watermarking scheme for copyright protection and temper detection. The secret key encryption algorithm is used for embedding the watermark using LSB technique. The verification (the watermark extraction) process uses the same key as in encryption, and hence it can be used for copyright protection of digital media such as images, audio and video.

Anuradha , Rudresh Pratap Singh [9]: A grayscale visual watermark image is inserted into the host color image using the Haar Wavelet Transform, where the copyright of Watermark is printed. This new technique has two properties high fidelity and robust.

Mr. Gaurav N Mehta, Mr. Yash Kshirsagar, Mr. Amish Tankariya (2012): This paper presents a digital image watermarking based on Discrete Wavelet Transform (DWT). In the proposed method, the watermark as well as the cover image seldom looses the quality in both embedding and extraction process. The embedding process is carried out by tetra-furcating the watermark and embedded into the sub-bands of cover image. Signal to Noise Ratio (SNR) and Peak Signal to Noise Ratio (PSNR) are computed to measure image quality for the DWT transform.

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.

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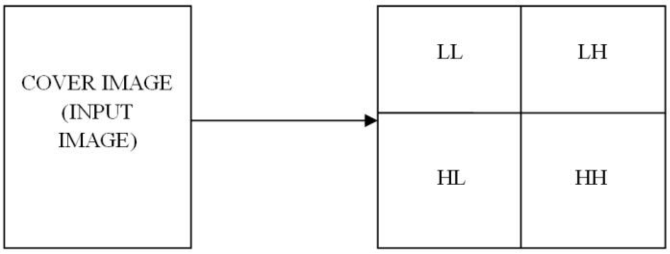

Fig 1: 1- Level DWT Decomposition

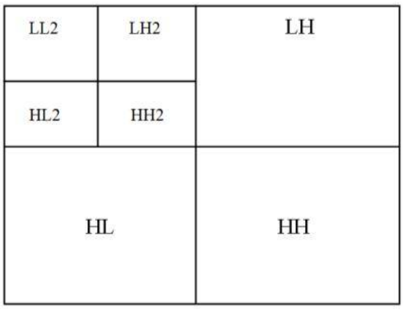

Fig 2: 2-Level DWT Decomposition

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:

1. Mean Squared Error (MSE): To determine the resemblance between the actual image and equivalent watermarked image an inaccuracy is calculated by subtracting the watermarked image pixel intensity values from the actual image pixel intensity values, and after that calculating the mean of the inaccurate signal. The Mean Squared Error is described by equation

$$MSE = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}\left(x(i,j) - y(i,j)\right)^2$$

Where i and j are the pixel positions of the image having M number of rows & N number of columns and *x(i, j)* is the pixel intensity values of actual image and *y*(*i, j*) is the pixel intensity values of corresponding watermarked image. Mean Squared Error is zero when pixel intensities of both the images are same.

2. Peak Signal to Noise Ratio (PSNR): The units of Peak Signal to Noise Ratio are decibels and it is inversely relative to the MSE (Mean Squared Error). It is specified by means of the equation

$$PSNR = 10log_{10}\frac{255}{\sqrt{MSE}}$$

Larger the cost of Peak Signal to Noise Ratio (PSNR) better is the superiority of the watermarked image.

3. Normalised Correlation (NC): Comparability of extracted watermark with the original watermark is quantitatively analyzed by using
correlation coefficient. Value of ρ is between 0 and 1. The bigger the value of ρ, better is the robustness of watermark.

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$$\rho(W,\overline{W}) = \frac{\sum_{t=1}^{r} W(i)\overline{W}(i)}{\sqrt{\sum_{t=1}^{r} \overline{W^2}(i)}\sqrt{\sum_{t=1}^{r} W^2(i)}}$$

Where *W* is the singular values of original watermark, is the extracted singular values and r=max(M1,N1).

D. EMBEDDING PROCESS:

- Read both input image and watermark image.
- Use 1–level DWT to decompose the input image into four aub-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:

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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 be the cost function which must be minimized or fitness function which must be maximized. Let x ∈ 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 {1, … … } (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 ≡ (0,1)
      - If r i < CR(crossover probabiltity) or i=R then set yi= + ∗(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 drom the population that has the highest fitness value or the lowest 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.

2. **Fitness Function:**
In this paper, we used NC and PSNR values as fitness function. Computing NC and 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 NC(Normalised Correlation) and 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 Normalised Correlation and Peak-Signal-to-Noise Ratio. High NC and 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.

i) **Normalised Correlation (NC):** Comparability of extracted watermark with the original watermark is quantitatively analyzed by using correlation coefficient. Value of ρ is between 0 and 1. The bigger the value of ρ, better is the robustness of watermark.

$$\rho(W,\overline{W}) = \frac{\sum_{t=1}^{r} W(i)\overline{W}(i)}{\sqrt{\sum_{t=1}^{r} \overline{W^2}(i)}\sqrt{\sum_{t=1}^{r} W^2(i)}}$$

Where *W* is the singular values of original watermark, is the extracted singular values and r=max(M1,N1).

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ii) **Peak Signal to Noise Ratio (PSNR):** The units of Peak Signal to Noise Ratio are decibels and it is inversely relative to the MSE (Mean Squared Error). It is specified by means of the equation

$$PSNR = 10log_{10}\frac{255}{\sqrt{MSE}}$$

Larger the cost of Peak Signal to Noise Ratio (PSNR) better is the superiority of the watermarked image.

IV. RESULTS AND GRAPHS

- The watermark Embedding and Extraction process has been shown in figure (3) & figure(4), Algorithms for Watermark Embedding use lena Image as input (256*256) and watermark Image of size (28*28). 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

GRAPH:

In Fig. 5, 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 sca we use iteration is of size 50

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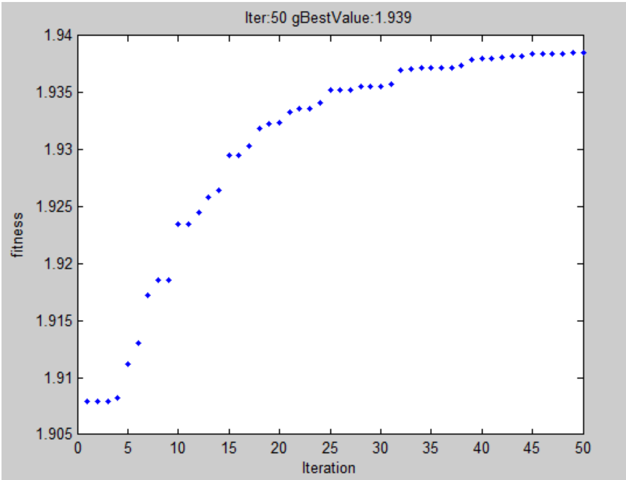
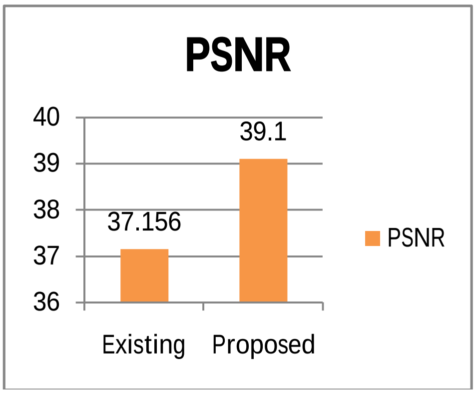


Figure 5: PSNR in case of Lena

Table 1 presents the results of Figure 5 . Table 1 demonstrates the optimized PSNR and NC value when lena image is used as input images. Figure 6 tells about the PSNR Comparison. Figure 7 tells about the NC Comparison on Existing Approach and Proposed Approach.

Table 1: Lena images on Existing approach and Proposed Approach

Approach	PSNR	NC
Existing	37.156	0.963
Proposed	39.1	1



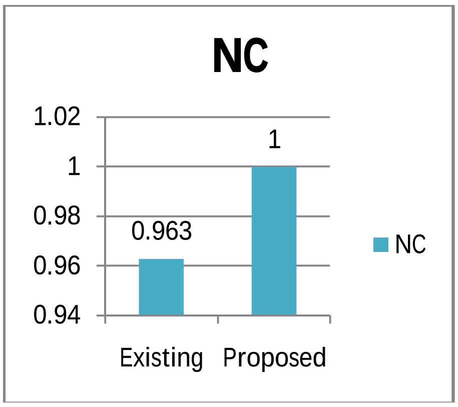


Figure 6: PSNR Comparison On Both Approaches

Figure 7: NC Comparison On Both Approaches

V. CONCLUSION

In this work, we gave the brief discussion of optimal scaling and fitness function(PSNR and NC). Existing approach work on static-scale whereas, Proposed approach use optimal scale. So, we conclude that we increase the PSNR and NC value. We increase the PSNR upto 1.944 and NC upto 0..37 from existing approach to proposed approach. In Optimal Scale, the value varies all the time and also gave good result from existing to proposed work.

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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 and NC as fitness function for the efficiency of image. But in future we would also use Hybrid Technique as DE-PSO to get more Optimal solution.

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