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# A BLIND IMAGE WATERMARKING TECHNIQUE USING MOST FREQUENT WAVELET COEFFICIENTS

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***Abstract- Watermarking in multimedia contents has attracted lots of attention in the research society. In this approach wavelet based blind image watermarking technique is proposed, initially original image is undergoing a single level decomposition using wavelet transform. From the approximation band, remove the decimal part of the most repeated integer part. Now, secret information is multiplied by the scaling factor which provides embedding strength. Further, it is added to the repeated values of wavelet coefficients, the watermarked image is obtained by applying the inverse wavelet transform. To prove the ownership extract the watermark by identifying the most frequent coefficients of the single level decomposition of watermarked image. Simulation results displays that the proposed approach can withstand the noise and filtering attacks with a good invisibility and robustness.***

**Index terms*:* Authentication, Copyright protection, Most frequent coefficients, Watermarking, Wavelet transform.**

# I. INTRODUCTION

Due to fast growing of multimedia communication means that the digital contents are transmitted more easily. During distribution unknown are acquired the data and claim ownership. Hence, the protection of intellectual property is an important consideration for the society [1-2]. Various researchers have been drilled down the answers for copyright protection. The best way, in which the multimedia information is ensured against illegal transmission and recording is to put a signal on the cover medium for the confirmation of the proprietor of the information.

A technique that tends to conceal the copyright information into the digital media is called Digital Watermarking. A Human cannot visualize the message with an eye and perceives it as a normal cover medium [3-4]. Digital watermarking has gained more attention while proving the integrity and authenticity of the owner [5-7]. Hence the industry and academic people are working seriously on digital watermarking. Figure 1 shows that the basic components of watermarking technique. In this block diagram the copyright watermark image is embedded into the original image by using a secret key and obtained the watermarked image.

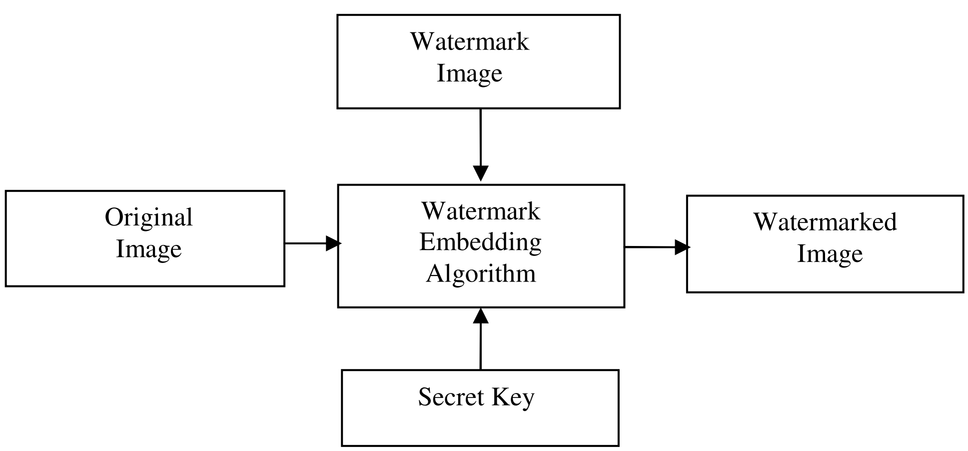


Figure 1. Basic components of watermarking technique

Blind watermarking scheme [8], is the most challenging type of watermarking system because it doesn't require host image during extraction. The two different embedding approaches in watermarking systems are spatial and transform domain [9]. In the spatial watermarking technique is quite easy to embed a watermark into a host image by changing the pixel values directly using bit substitution. Transform domain techniques are more robust and stable because secret information is inserted into the transform coefficients [10-11]. Applications of watermarking techniques are duplicate control, fingerprinting, evidence of ownership, authentication, broadcast monitoring, etc.

The wavelet transform plays a vital role in the field of image processing applications[12-14] like compression, signal processing, edge detection digital watermarking, etc., A mathematical function which is used to divide a continuous-time signal into different scale components is referred as wavelet. A wavelet is a waveform of an effectively limited duration that has an average value of zero. The Discrete Wavelet Transform (DWT) is obtained by filtering the signal through a series of digital filters at different scales [15].

The scaling operation can be achieved by modifying the resolution of the signal by the process of subsampling. The DWT is computed by successive low-pass and high-pass filtering of the discrete time-domain signal. The basic idea of the DWT for two-dimensional images is first decomposed into four parts of high, middle, and low-frequency sub-components $LL_1$, $LH_1$, $HL_1$, and $HH_1$ [16-17] by critically sub- sampling horizontal and vertical channels using sub-component filters. The high- frequency part contains edge components, wherein the $LL_1$ frequency band contains information components. In order to obtain the second level decomposition, the sub-component $LL_1$ is further decomposed and critically sub-sampled to $LL_2$, $LH_2$, $HL_2$, and $HH_2$. Figure 2 shows the two-level decomposition of an image under DWT. The discrete wavelet coefficients can be acquired by expanding the function $f(x)$ as a sequence of numbers. By applying the principle of series expansion, the discrete wavelet transform coefficients are defined as,

$$W\varphi(j_0, k) = \frac{1}{\sqrt{M}} \sum_x f(x) \varphi_{j0,x}(x) \tag{1}$$

$$W\psi(j, k) = \frac{1}{\sqrt{M}} \sum_x f(x) \psi_{j,k}(x) \tag{2}$$

For $j \geq j_0$ and the $W\varphi(j_0,k)$ and $W\psi(j, k)$ are the approximation coefficient and detail coefficient respectively. The parameter $M$ is a power of 2 which ranges from 0 to $J-1$. The DWT coefficients enable us to reconstruct the signal function $f(x)$ as,

$$f(x) = \frac{1}{\sqrt{M}} \sum_k W\varphi(j_0, k)\varphi_{j0,k}(x) + \frac{1}{\sqrt{M}} \sum_{j=jo}^{\infty} W\psi(j\ ,k)\psi_{j,k}(x) \qquad (3)$$

Where $1/\sqrt{M}$ is a normalizing factor. The reason that the discrete wavelet transform is a better transform because DWT have a better ability in localizing both time and frequency. In the watermarking application, the secret information is concealed in lower level or medium level sub-band of the decomposed image. Among the proposed methods in the recent years, DWT deserves more popularity due to their excellent spatial localization, frequency spread, and multi-resolution characteristics are computationally more efficient than other transform methods. In DWT only sum or difference of the pixel is calculated, the results it acquires more speed than DCT and DFT.

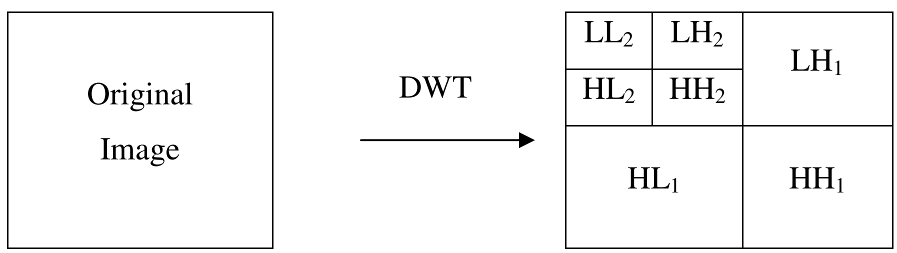


Figure 2. Two level DWT Decomposition

Benefits towards the DWT are the selection of proper sub-bands in the case of robustness and imperceptibility. The original signal can also be reconstructed from the knowledge of DWT coefficients. This process is called Inverse Discrete Wavelet Transform (IDWT).

## II. LITERATURE REVIEW

Many algorithms have been put forward in the scientific review. Hsiang-Cheh Huang *et al.* (2010) presented the optimization of robust watermarking using bacterial foraging optimization algorithm. By finding tradeoffs among different watermark robustness and imperceptibility, and considering the adaptive tuning of weighting factors, we design a practical fitness function for optimization. Simulation results depict the better performances over existing implementations with GA, and hence fuzzy-based BF can be considered to be another practical optimized watermarking scheme.

Aree Ali Mohammed &Haval Mohammed Sidqi (2011) proposed an image watermarking scheme based on multi bands wavelet transformation method. At first, the proposed scheme is tested on the spatial domain (for both a non and semi blind techniques) in order to compare its results with a frequency domain. In the frequency domain, an adaptive scheme is designed and implemented based on the bands selection criteria to embed the watermark. These criteria depend on the number of wavelet passes. In this work three methods are developed to embed the watermark selection. This is advantage of the scheme is the involvement of a large number of wavelet bands in the embedding process.

Surekha & Sumathi (2011), proposed a discrete wavelet transformed based image watermarking algorithm by using genetic algorithm. The amplification factor of the watermark is the significant parameter that helps in improving the perceptual transparency and robustness against attacks. The tradeoff between the transparency and robustness is considered as an optimization problem and is solved by applying Genetic Algorithm.

Abdallah *et al.* (2011), proposed a wavelet based watermarking and uses blind wavelet based watermarking. In this watermark is inserted in the coarsest scale wavelet coefficients. Wavelet divides the image into 3-levels and watermark is embed into the coarse scale. This scheme depends on the quantization of certain wavelet coefficients within certain amplitude ranges in a binary manner to embed meaningful information in the image.

Ray-Shine *et al.* (2012) proposed two methods to improve the reliability and robustness. To improve the reliability, for the first method, the principal components of the watermark are embedded into the host image in discrete cosine transform (DCT); and for the second method, those are embedded into the host image in discrete wavelets transform (DWT). To improve the robustness, the particle swarm optimization (PSO) is used for finding the suitable scaling factors. The experimental results demonstrate that the performance of the proposed methods outperforms than those of the existing methods.

Sridhar and Arun (2012) propose a multiple watermarking based on DWT with the motivation to maintain the quality of the image. The original image was interlacing into even and odd rows of images and deinterlaces the two images. For hiding watermark images wavelet based approach is employed in two deinterlace images. Stack the two watermarked images in to single image by introducing zeros of even and odd rows in the two watermarked images, At the end again interlacing and deinterlacing of an images and extracts both the watermark Images. Simulation results show the watermark imperceptibility and robustness. Also the quality of the watermarked image is excellent and there is strong resistant against many geometrical attacks.

Sridhar and Arun (2013) propose a watermarking technique based on wavelet domain and sharing of an image with the motivation to maintain the quality of the image. The original image is diagonally shared and one of the shares is horizontally merged and watermarking process is employed in fusion image using wavelet. Further breakaway the pixels into normal share. Stack the two watermarked images in to single image. At the receiver end again shared and merged a watermarked share in horizontally and extracts a watermark Image. Simulation results indicate that the proposed watermarking scheme is highly robust and does not reduce the quality of watermark image.

Sonil Sood & Ajai Goyal (2014) proposes a novel method for watermarking relational databases based on hybrid model optimization in which the embedding and extracting algorithms of watermarking in discrete wavelet transform (DWT) are combined with Genetic Algorithm (GA)-Bacterial Foraging Algorithm (BFO) based optimization techniques for watermarking. In this 5-level DWT is employed in the spatial transform; because of the more accurate watermark. Identification of owner is cryptographically made secure and used as an embedded watermark. Strength of BFA is explored to make the technique robust, secure and imperceptible.

Yahya AL-Nabhani et al.(2015) developed discrete wavelet transform with a Haar filter to embed a binary watermark image in selected coefficient blocks. A probabilistic neural network is used to extract the watermark image. To evaluate the efficiency of the algorithm and the quality of the extracted watermark images, widely known image quality function measurements are used, such as peak signal-to-noise ratio (PSNR) and normalized cross correlation (NCC). Results indicate the excellent invisibility of the extracted watermark image as well as exceptional watermark extraction. Experimental results reveal that the proposed watermarking algorithm yields watermarked images with superior imperceptibility and robustness to common attacks, such as JPEG compression, rotation, Gaussian noise, cropping, and median filter.

## III. PROPOSED APPROACH

This proposed scheme adds the watermarks into the most frequent integer part of wavelet coefficients, initially original gray image $[Y]_{m \times n}$ is undergone the single level wavelet decomposition as shown in equation 4. Where $Y_{ll}$, $Y_{lh}$, $Y_{hl}$, $Y_{hh}$ are the sub bands of the $Y$. Consider only the low level (*LL*) sub band wavelet coefficients, because embedding in lower sub band yields more resistant to compression and filtering attacks.

In *LL* sub band remove the decimal part of the most frequent integral part. The size of the watermark image (*W*) is modified according to the count of most frequent value. Scaling function (α) provides the embedding strength and finally scaled watermark information is directly added to the mode values of the lower sub band matrix. Inverse DWT is applied and obtain a watermarked image. During the extraction apply the single level decomposition to the watermarked image, identified the most frequent integer part in the lower sub band and read only the decimal parts. Extracted watermark image is obtained by dividing the decimal parts of most frequent value by the scaling factor(α).

In the example matrices 6 is occurring 12 times in the most frequently in the low level coefficients. Now remove the decimal parts of most frequent coefficients. Scaled Watermark matrix is directly added to the decimal part of most frequent coefficients. Below algorithm gives the procedure of watermark embedding.

**Algorithm:** Watermark in most frequent wavelet coefficients

***Begin:***

*for i=1 to Rows do*

*for j= 1 to Columns do*

```
        Read only integer part
          If integer number and mode number are equal,
              Remove decimal numbers
              Watermarked =Integer Value+α*Watermark(count)
          Count=Count+1;
          else
          Do nothing
          endif
        end
      end
end
```

$$[Y]_{mxn} \xrightarrow{DWT} \begin{bmatrix} Y_{ll} & Y_{lh} \\ Y_{hl} & Y_{hh} \end{bmatrix}_{mxn} \tag{4}$$

$$Y_{ll}^{'} = \begin{pmatrix} 5.1243 & 0.9864 & 1.2034 & \mathbf{6.0000} & 2.3122 & \mathbf{6.0000} \\ 3.1267 & \mathbf{6.0000} & 8.1981 & 2.9087 & \mathbf{6.0000} & 3.1244 \\ \mathbf{6.0000} & 1.2345 & 2.0345 & 3.1234 & \mathbf{6.0000} & 5.1234 \\ \mathbf{6.0000} & 2.1093 & \mathbf{6.0000} & \mathbf{6.0000} & 0.0002 & 3.0031 \\ 3.7321 & \mathbf{6.0000} & 1.2341 & 3.9123 & \mathbf{6.0000} & 1.0023 \\ 7.7438 & 5.8493 & \mathbf{6.0000} & 4.7439 & 0.0974 & 5.0938 \end{pmatrix} \tag{5}$$

$$W = \begin{pmatrix} 1 & 2 & 3 & 4 \\ 5 & 6 & 7 & 8 \\ 9 & 10 & 11 & 12 \end{pmatrix} \tag{6}$$

$$E=\begin{pmatrix} 5.1243 & 0.9864 & 1.2034 & \mathbf{6.0001} & 2.3122 & \mathbf{6.0002} \\ 3.1267 & \mathbf{6.0003} & 8.1981 & 2.9087 & \mathbf{6.0004} & 3.1244 \\ \mathbf{6.0005} & 1.2345 & 2.0345 & 3.1234 & \mathbf{6.0006} & 5.1234 \\ \mathbf{6.0007} & 2.1093 & \mathbf{6.0008} & \mathbf{6.0009} & 0.0002 & 3.0031 \\ 3.7321 & \mathbf{6.0010} & 1.2341 & 3.9123 & \mathbf{6.0011} & 1.0023 \\ 7.7438 & 5.8493 & \mathbf{6.0012} & 4.7439 & 0.0974 & 5.0938 \end{pmatrix} \quad (7)$$

$$\begin{bmatrix} E & Y_{lh} \\ Y_{hl} & Y_{hh} \end{bmatrix}_{mxn} \xrightarrow{IDWT} [Y^{'}]_{mxn} \quad (8)$$

## IV. RESULTS AND DISCUSSION

The performance of the proposed watermarking scheme is implemented using MATLAB. For concealing the watermarked image, we used a standard image like the cameraman image of size 512x512 and the watermark information like finger print image of size 120x60. Figure 3 displays the original cover image, watermark image, watermarked cover image and extraction of the watermark image. In a cover image the most repeated integer part of the lower sub band is 28 and the number of time occurs is 1387.

The performance of various schemes of watermarking can be evaluated on the bases of some of the visual quality matrices [27-29] given in equations 9 and 10. Peak Signal to Noise Ratio (PSNR) and the Mean Square Error (MSE) are present the idea about the visual degradations of the watermarked cover medium, the strength of both watermark and the robustness of the algorithm.

$$MSE = \frac{1}{MN}\sum_{i=0}^{M-1}\sum_{j=0}^{N-1}[X(i,j)-Y(i,j)]^2 \quad (9)$$

$$PSNR = 10\log_{10}[255^2 / MSE] \quad (10)$$

An error value between the original video frame *X(i, j)* and the extracted video frame *Y(i, j)* is called Mean Square Error, where M and N are the size of the image.

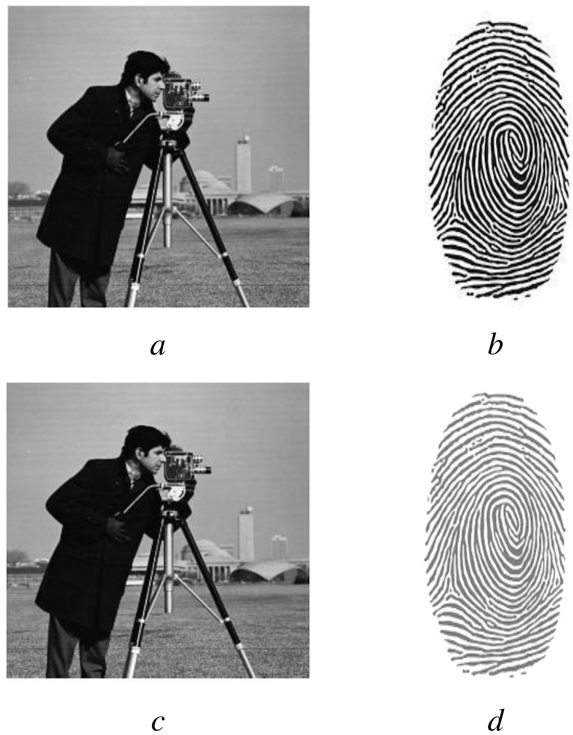

Figure 3. (a) Original Image; (b) Watermark Image; (c) Watermarked Image; (d) Extracted Watermark.

PSNR used to measure the quality of the original and the watermarked image. PSNR and MSE of our proposed approach are 84.6773dB and 0.0004 respectively. The time taken to embedding the watermark information in the most frequent wavelet coefficients is only 1.3028 seconds. In order to examine the robustness of our experiment, we introduce noise attacks with noise density 0.02 and also, the median filtering attack is introduced to measure the robustness. The results yield that our method gives the reasonable PSNR against various attacks. Overall performance of watermarked and extracted watermark image is indicated in Table 1.

Table 1. Performance of PSNR values of our proposed approach.

| **Attacks** | **Watermarked Image** | **Extracted Watermark** |
|---|---|---|
| | PSNR(dB) | PSNR(dB) |
| No attacks | 84.6773 | 30.5779 |
| Salt & Pepper noise | 47.3543 | 28.6037 |
| Poisson noise | 32.0258 | 28.5297 |
| Speckle noise | 30.6523 | 28.5838 |
| Gaussian noise | 29.4768 | 28.5425 |
| Median filtering | 35.9631 | 28.8368 |

## V. CONCLUSION

In this paper, a wavelet based blind digital image watermarking algorithm using most frequent wavelet coefficients is proposed. The experimental results show that this approach is robust against noise and filtering attacks. Here, concealed the copyright information only in the most repeated wavelet coefficients, hence we achieved the degree quality is high. PSNR and Correlation coefficient of our method are 84.6773dB and 0.9996. This proposed approach is simple, efficient and with less complexity. In future the enhancement of this algorithm will be extended to video.

## REFERENCES

[1] Li, Q., and Cox, I.J, "Using perceptual models to improve fidelity and provide resistance to valumetric scaling for quantization index modulation watermarking", IEEE Transaction on Information Forensics and Security, Vol.2, no.2,2007, pp.127–139.

[2] Chen Yongqiang, Zhang Yangqing and Peng Lisen, "A Novel Optimal Color Image Watermarking Scheme", In: 3rd International Conference on Genetic and Evolutionary Computing, 2009, pp.121-124.

[3] Podilchuk, CI and Delp, EJ, "Digital watermarking: Algorithms and applications", IEEE Signal Processing Magazine, vol. 18, no. 4, 2001,pp. 33-46.

[4] Chandramouli, R, Memon, ND and Rabbani, M, "Digital watermarking:in Encyclopedia of imaging Science and Technology", Wiley, 2002.

[5] Yiwei Wang, John Doherty, F and Robert VanDyck, E, "A Wavelet Based Watermarking Algorithm for Ownership Verification of Digital Images", IEEE Transactions on Image Processing, vol. 11, no. 2, 2002,pp. 77-88.

[6] Piva, A, Bartolini, F and Barni, M, "Managing copyright in open networks", IEEE Transactions on Internet Computing, vol. 6, no. 3, 2002, pp. 18-26.

[7] Vidyasagar, M.Potdar , SongHan and ElizabethChang, "A Survey of Digital Image Watermarking Techniques", 3rd International Conference on Industrial Informatics (INDIN),2005, pp. 709-713.

[8] Henri Bruno Razafindradina and Attoumani Mohamed Karim, "Blind and Robust Images Watermarking based on Wavelet and Edge Insertion", International Journal on Cryptography and Information Security (IJCIS), Vol.3, no.3,2013, pp. 23-30.

[9] Shih, F.Y. and Wu, S.Y.T., "Combinational image watermarking in the spatial and frequency domains", Pattern Recognition, Vol.36,2003, pp.969–975.

[10] Alessandro Piva, Tiziano Bianchi, and Alessia De Rosa, " Secure Client-Side ST-DM Watermark Embedding", IEEE Transactions on Information Forensics and Security, Vol.5, no.1,2010, pp.13-26.

[11] Suhail, M.A.,and Obaidat, M. S., "Digital watermarking-based DCT and JPEG model", IEEE Transaction on Instrumentation and Measurement, Vol.52, no.5, 2003, pp.1640–1647.

[12] Mallat, S, "A Wavelet Tour of Signal Processing", Academic, San Diego, 1998.

[13] Ganic, E and Eskicioglu, AM, "Robust DWT-SVD domain image watermarking: embedding data in all frequencies", In Proceedings of the ACM Multimedia and Security Workshop, 2004, pp. 166-174.

[14] Olkkonen, H, Discrete Wavelet Transforms - Algorithms and Applications, InTech,2011.

[15] Jayaraman, S, Esakkirajan, S and Veerakumar, T, Digital Image Processing, McGraw Hill Education(India) Private Limited, New Delhi, 2013.

[16] Masataka Ejima and Akio Miyazaki, "A Wavelet-Based Watermarking for Digital Images and Video", ICIP 2000, pp. 678-681.

[17] Yuanyu Ding , Xiaoshi Zheng, Yanling Zhao and Guangqi Liu, "A Video Watermarking Algorithm Resistant to Copy Attack", in Third International Symposium on Electronic Commerce and Security (ISECS), 2010,pp. 289-292.

[18] Hsiang-Cheh Huang, Yueh-Hong Chen and Ajith Abraham, “Optimized Watermarking Using Swarm Based Bacterial Foraging”, Journal of Information Hiding and Multimedia Signal Processing, Vol. 1,no. 1, 2010.

[19] Aree Ali Mohammed and Haval Mohammed Sidqi, “Robust Image Watermarking Scheme Based on Wavelet Technique”, International Journal of Computer Science and Security (IJCSS), Vol. 5, no.4, 2011.

[20] Surekha, P, and Sumathi,S, “Implementation of genetic algorithm for a dwt based image watermarking scheme”, ICTACT Journal on Soft Computing: Special issue on fuzzy in industrial and process automation, Vol. 2, no.1, 2011.

[21] Hanaa A. Abdallah, Mohiy M. Hadhoud ,Abdalhameed A. Shaalan and Fathi E. Abd El-samie, “Blind Wavelet-Based Image Watermarking”, International Journal of Signal Processing, Image Processing and Pattern RecognitionVol. 4, No. 1, 2011.

[22] Ray-Shine Run, Shi-Jinn Horng, Jui-Lin Lai, TzongWang Kao, and Rong-Jian Chen, “An improved SVD based watermarking technique for copyright protection”, Expert Systems with Applications, Vol. 39, 2012.

[23] Sridhar, B, and Arun, C, “On secure multiple image watermarking techniques using DWT”, Computing Communication and Networking Technologies (ICCCNT), 2012 Third International Conference on, Coimbatore, 2012, pp. 1-4.doi: 10.1109/ICCCNT.2012.6395871

[24] Sridhar, B, and Arun, C, “A wavelet based image watermarking technique using image sharing method”, 2013 International Conference on Information Communication and Embedded Systems (ICICES), Chennai, 2013, pp. 629-633. doi: 10.1109/ICICES.2013.6508179

[25] Sonil Sood, and Ajay Goyal, “Watermarking Relational Databases using Genetic Algorithm and Bacterial Foraging Algorithm”, International Journal of Information and Computation Technology, Vol. 4, no.17, 2014.

[26] Yahya AL-Nabhani, Hamid A.Jalab, AinuddinWahid and Rafidah MdNoor, “Robust watermarking algorithm for digital images using discrete wavelet and probabilistic neural network”, Journal of King Saud University - Computer and Information Sciences,Vol. 27, no. 4, 2015, pp 393-401

[27] M. Kutter and F.A.P.Petitcolas, “A fair benchmark for image watermarking systems”, Electronic Imaging Security and Watermarking of Multimedia Contents, vol. 3657,1999, pp. 25-27.

[28] Fabien A.P. Petitcolas, “Watermarking Schemes Evaluation”, IEEE signal processing magazine, 2000, pp. 58-64.

[29] Mritha Ramalingam, “Stego Machine – Video Steganography using Modified LSB Algorithm”, World Academy of Science, Engineering and Technology 74, 2011, pp. 502-505.