# Adaptive Digital Image Watermarking Technique through Wavelet Texture Features

Sarita P. Ambadekar[1*], Dr. Jayshree Jain[2], Dr. Jayshree Khanapuri[1]
[1*]K. J. Somiaya Institute of Engineering & Information Technology, Mumbai, India.
[2] Pacific Academy of Higher and Research Univeristy, Udaipur, India.

**Abstract.** Remarkable advancement in social media websites and chats, sharing photos, audios and videos is become very easy and dangerous. Digital image watermarking technique has the potential to address the issue of privacy, ownership and authenticity of the media shared using such medium. Invisible digital image watermarking techniques are necessary which are imperceptible within host image and robust to common signal and image processing attacks. In this paper, we present a watermarking technique for digital images through adaptive texturization, statistical parameters and Bhattacharya distance. The primary idea is to segment the host image into four different regions based frequency distribution using discrete wavelet transform. Subsequently important statistical parameters mostly applied in image processing techniques such as mean, standard deviation, skew, kurtosis and variance are calculated from the wavelet transform coefficients of each regions of host and watermark image. These statistical parameters of segmented regions of host and watermark image are then applied to obtain Bhattacharya distance. Wavelet transform coefficients of watermark image are embedded into wavelet transform coefficients of one of the region of carrier image with minimum Bhattacharya distance through embedding factor. Performance of the technique was tested on multiple host and watermark images under common image processing attacks, which yield better results.

**Keywords:** Digital Image Watermarking, Discrete Wavelet Transform (DWT), Statistical parameters, Bhattacharya distance, Embedding factor.

## 1 Introduction

The remarkable development in very high speed local area network (LAN), wide area network (WAN), metropolitan area network (MAN), internet technology and social media websites and chats sharing of photos, audios and videos are become very easy and dangerous. Due to sharing of digital multimedia documents such as images, audios and video sequences by uploading / downloading / circulating / forwarding intentionally or unintentionally on social media websites such as Facebook, Twitter, LinkedIn, what's app, etc. Manipulating, copying and moderating of data are very simple since one and all have got access to the data / information through several signal and image processing algorithms. Furthermore an original copy of digital images, videos is not distinguishable from the inventive record. Hence copyright protection and owner authentication has been more and more challenging tasks for multimedia data [1 – 3]. Nowadays it has been extremely necessary to propose, innovate, design and develop an image processing algorithm for copyright protection, protection against duplication, and authentication of digital multimedia contents. Digital watermark is a message / data / information which are exactly simpler to digital signature. This signature is then embedded into digital multimedia files that can be detected or extracted later to prove the authenticity of the owner or inventor [4] – [6]. The complete method of embedding / extracting digital watermark information in the form of signature (text / image) into digital multimedia content is termed as digital watermarking. Sharing / posting / uploading an image on website require resizing, contrast adjustments, cropping and compression through JPEG or any other compression algorithms which may result in partial or complete damage to host image that requires sophisticated image processing and watermarking algorithms.

Digital image watermarking techniques has been focus of many researchers since last two / three decades. The major objective of the digital image watermarking techniques is to proven the authenticity of the documents as when challenged by comparing extracted watermark with the original watermark [7] – [9]. Watermarking is interesting to investigate due to several reasons such as invisibility and robustness to various signal and image processing attacks such as cropping, geometric rotations, noise attack and deformations. Therefore watermarking technique necessarily requires handling of in image imperceptibility, resistant to attacks, large number of watermarks and robustness. Combinations of spatial and transformed domains techniques have been leverage by many engineers and researchers to take advantages of both the domains. Also various other mathematical and statistical models and many other mostly applied interdisciplinary approaches in digital image processing: such as chaotic theory, fractal image coding, adaptive techniques, etc are explored. Transformed domain techniques using DCT and DWT are also exploited to embed digital image watermark into host image [10]. In [11] maximum entropy subband of the carrier image was explored for digital image watermarking, also subbands of the logo were shuffled to provide security to watermarked image. In [12] combination of DWT with singular value decomposition (SVD) techniques was presented for watermarking. In this method singular value matrix is embedded into the carrier image whereas remaining two unitary matrices are left intact which contents significant information. Whereas during extraction process these two unitary matrices are employed resulting in better robustness. In [13] watermark image was encrypted into random noise signal before watermarked into host image through DWT to enhance its security. Whereas in [14] Arnold transform was employed to enhance the security of the watermark image. Thereafter the logo embedded into LL subband of the carrier image that contains the high magnitude coefficients. In [6] proposed to identify region in carrier image for watermarking, thereafter the statistical properties of the region where employed to obtain a fusion of digital image watermark and statistical image synthesis for invisible image watermarking. However it is desired to build an invisible image watermarking technique that employs previously known techniques but adopting adaptive techniques without sacrificing on the security of the watermark. In this paper, we present a watermarking technique for digital images through adaptive texturization, statistical parameters and Bhattacharya distance. The primary idea is to segment the host image into four different regions based frequency distribution using discrete wavelet transform. Subsequently important statistical parameters mostly applied in image processing techniques such as mean, standard deviation, skew, kurtosis and variance are calculated from the wavelet transform coefficients of each regions of host and watermark image. These statistical parameters of segmented regions of host and watermark image are then applied to obtain Bhattacharya distance. Wavelet transform coefficients of watermark image are embedded into wavelet transform coefficients of one of the region of carrier image with minimum Bhattacharya distance through embedding factor. Performance of the technique was tested on multiple host and watermark images under common image processing attacks, which yield better results.

The paper is systematically prepared as section 2 illustrates the embedding and extraction procedure, section 3 demonstrates simulation results and finally conclusion derived from the results is stated in section 4.

## 2 Watermark Embedding & Extraction Procedure

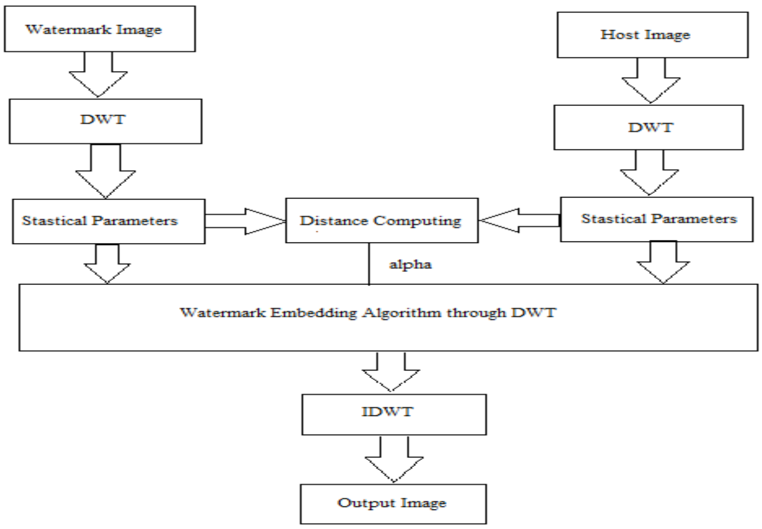



**Fig. 1.** Stages in digital image watermarking using block diagram

Digital image watermark embedding algorithm comprises several stages as segmentation in frequency using DWT, statistical parameter extraction, computing Bhattacharya distance and watermark embedding in frequency / wavelet domain. Robustness of the proposed algorithm is enhanced by embedding all frequency / wavelet coefficients of watermark image into frequency / wavelet coefficients of selected region of host image. Whereas computing Bhattacharya distance in this manner enhances imperceptibility through matching texture of watermark image with the region of host image. Fig. 1 shows the several stages in digital image watermarking through block diagram and it's embedding and extraction procedure is explained.

*2.1 Watermark Embedding Procedure*

Let input host image (I) and watermark image (w) are 8-bit gray scale of the size p x q. Watermark embedding algorithm is detailed point wise as follows

1. Read the input host (I) and watermark (w) image.
2. Convert color host and logo image into gray scale image.
3. Host image was segmented into four regions to identify best region for watermark embedding.
4. Each segmented region of host image (I) was decomposed into four (4) subbands LL, LH, HL and HH using Debauches 2D DWT.
5. Similarly watermark image was decomposed into four (4) subbands LL, LH, HL and HH using Debauches 2D DWT.
6. Determine statistical parameters such mean (μ), standard deviation (σ), variance (ν), skew (α) and kurtosis (γ) for each region of the carrier image and logo.

$$\mu_{mn} = \frac{E_{mn}}{p\ x\ q} \quad (1)$$

$$\sigma_{mn} = \frac{\sqrt{\sum_x \sum_y (|G_{mn}(x,y)| - \mu_{mn})^2}}{(p\ x\ q) - 1} \quad (2)$$

$$v_{mn} = \frac{\sum_x \sum_y (|G_{mn}(x,y)| - \mu_{mn})^2}{(p\ x\ q) - 1} \quad (3)$$

$$\alpha_{mn} = \frac{\sum_x \sum_y (|G_{mn}(x,y)| - \mu_{mn})^3}{\sigma^3} \quad (4)$$

$$\gamma_{mn} = \frac{\sum_x \sum_y (|G_{mn}(x,y)| - \mu_{mn})^4}{\sigma^4} \quad (5)$$

7. Determine the Bhattacharya distance $(d_{xy})$ between each subbands of the region of carrier image and logo.

$$d_{xy} = 0.125 * \left(\frac{(\mu_x - \mu_y)}{v_{xy}}\right) * \left(\frac{(\mu_x - \mu_y)}{v_{xy}}\right)^T + 0.5 * \log\left(\frac{v_{xy}}{\sqrt{v_x + v_y}}\right) \quad (6)$$

Where $v_{xy} = \frac{(v_x + v_y)}{2}$ (7)

8. Determine embedding factor alpha for each subbands through Bhattacharya distance and visibility controlling factor k.

$$alpha = k * \frac{1}{(1 + e^{d_{xy}})} \quad (8)$$

9. Embed the wavelet coefficients of logo image into least Bhattacharya distance region of the carrier image through alpha an embedding factor.

$$Ie(x,y) = \left(alpha * w(x,y)\right) + I(x,y) \quad (9)$$

10. Two (2) dimensional Debauches (2D) IDWT is applied on the LL, LH, HL and HH subband coefficients of the watermark embedded host image $(Ie)$.

The complete process of watermark embedding into input host image through wavelet domain is described in the algorithm whereas the process of watermark extraction is discussed in next section.

*2.2 Watermark Extraction Procedure*

Let $I_e$ and $I$ represents watermark embedded and host image of the size $p \times q$ respectively. The steps involved in the complete process of extraction of watermark from the host image are illustrated as follows.

1. Read the original host and watermarked host image of the size $p \times q$.
2. Convert color host image into gray scale image.
3. Watermarked host and original host image was segmented into four regions.
4. Each region of watermark embedded host image was decomposed into four subbands LL, LH, HL and HH using Debauches 2D DWT.
5. Similarly each region of the carrier image was decomposed into four (4) subbands LL, LH, HL and HH using Debauches 2D DWT.
6. Extract watermark from the each region of the watermarked host and original watermarked image through embedding factor alpha.

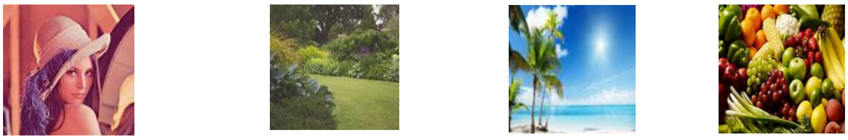
$$w(x,y) = \frac{\left(I_e(x,y) - I(x,y)\right)}{alpha} \tag{10}$$

7. Two (2) dimensional Debauches (2D) IDWT is applied on the resultant all subband coefficients of watermark image.
8. Determine the watermarking parameters between original and extracted watermark image with and without image processing attacks such as noise, compression and geometric.

The complete process of embedding and extraction of watermark is discussed in this section, simulation results obtained after implementation of the above algorithm using computer programming language MATLAB is discussed in next section.

## 3 Simulation Results

The comprehensive qualitative and measurable performance evaluation of proposed adaptive technique using adaptive texturization, statistical parameters and Bhattacharya distance is presented in this section. Fig. 2 depicts the several host images and watermark image applied for demonstrations, which are classified based on varying texturization. Image lena with ironic mix of directional texture which is distributed globally all over the entire image. Image garden has ironic mix of undirectional / random texture all over the host image. Whereas images fruits and scenery are poor in texture with fewer distribution all over the images and more color concentration in small areas. Performance evaluation of the proposed algorithm through peak signal to noise ratio (PSNR) and normalized correlation coefficient (NCC) was attempted. Robustness of the algorithm was measured by introducing rotation a geometrical attack, salt and pepper noise attack and JPEG compression attack. Fig. 3 and 4 shows the respective extracted watermark images from lena, garden, scenery and fruits host images without and with introduction of above attacks respectively.



Lena Garden Scenery Fruits

(a) Carrier images


(b) Watermark image

**Fig. 2.** Host and watermark images

**Fig. 3.** Retrieved watermark images from host image without attacks

(a) Noise (b) Geometric (c) Compression

**Fig. 4.** Retrieved watermark images from host image after several attacks

The measured parameters PSNR and NCC are depicted in table 1 & 2 for the retrieved watermark images without and with introduction of above attacks respectively. Comparison of proposed method with similar method proposed in [8] is depicted in table 3. The method in [8] does not segment host image into four regions for effective texture matching between host and watermark images.

**Table 1.** PSNR & CC Parameters without geometric, noise and compression attack

| Parameters | Lena | Garden | Scenery | Fruits |
|---|---|---|---|---|
| **PSNR (dB)** | 61.48 | 62.37 | 62.56 | 62.4 |
| **NCC** | 0.83 | 0.89 | 0.92 | 0.82 |

**Table 2.** PSNR & CC Parameters with geometric, noise and compression attack

| Attacks | Parameters | Lena | Garden | Fruits |
|---|---|---|---|---|
| **Noise** | **PSNR (dB)** | 41.24 | 40.67 | 39.43 |
| | **NCC** | 0.51 | 0.52 | 0.49 |
| **Geometric** | **PSNR (dB)** | 38.95 | 37.23 | 36.45 |
| | **NCC** | 0.65 | 0.66 | 0.67 |
| **Compression** | **PSNR (dB)** | 34.54 | 35.66 | 36.73 |
| | **NCC** | 0.56 | 0.57 | 0.59 |

**Table 3.** Comparison of the proposed method through PSNR & CC values for lena image

| Parameters | | Proposed method | [8] |
|---|---|---|---|
| PSNR (dB) | Without attack | 61.48 | 47.79 |
| CC | | 0.83 | 1.0 |
| PSNR (dB) | With noise attack | 41.24 | 32.15 |
| CC | | 0.51 | 0.1458 |

## 4 Conclusion

In this paper, we present a watermarking technique for digital images through adaptive texturization, statistical parameters and Bhattacharya distance. The primary idea is to segment the host image into four different regions based frequency distribution using discrete wavelet transform. Subsequently important statistical parameters mostly applied in image processing techniques such as mean, standard deviation, skew, kurtosis and variance are calculated from the wavelet transform coefficients of each regions of host and watermark image. These statistical parameters of segmented regions of host and watermark image are then applied to obtain Bhattacharya distance. Wavelet transform coefficients of watermark image are embedded into wavelet transform coefficients of one of the region of carrier image with minimum Bhattacharya distance through embedding factor. Several host images and watermark image applied for demonstrations were classified based on varying texturization. Images with ironic mix of directional texture and undirectional / random texture all over the host image also images with poor in texture and more color concentration in small areas. Adaptive frequency domain approach suggests better watermarking technique in terms of robustness and imperceptibility. Further security of the watermark image can be added to the existing algorithm to make it more secure through adopting encryption algorithms.

## References


[1] M. Natarajan and G. Makhdumi, "Safeguarding the digital contents: Digital watermarking," DESIDOC J. Library Inf. Technol., vol. 29, no. 3, pp. 29–35, 2009.

[2] C. I. Podilchuk and E. J. Delp, "Digital watermarking: Algorithms and applications," IEEE Signal Process. Mag., vol. 18, no. 4, pp. 33–46, Jul. 2001.

[3] X. Zhao and A. T. S. Ho, "An introduction to robust transform based image watermarking techniques," in Intelligent Multimedia Analysis for Security Applications, vol. 282. Berlin, Germany: Springer-Verlag, 2010, pp. 337–364.

[4] R. Halder, S. Pal, and A. Cortesi, "Watermarking techniques for relational databases: Survey, classification and comparison," J. Universal Comput. Sci., vol. 16, no. 21, pp. 3164–3190, 2010.

[5] A. Nema and R. Mohan, "Digital image watermarking: A review," Global J. Multidiscipl. Stud., vol. 3, no. 6, pp. 84–94, 2014.

[6] Mehran Andalibi and Damon M. Chandler, "Digital Image Watermarking via Adaptive Logo Texturization," in IEEE Transactions On Image Processing, Vol. 24, No. 12, December 2015, pp 5060 – 5073.

[7] Xiaosheng Huang, Sujuan Zhao, "An Adaptive Digital Image Watermarking Algorithm Based on Morphological Haar Wavelet Transform," in International Conference on Solid State Devices and Materials Science, Published by Elsevier Physics Procedia 25, 2012, pp 568 – 575.

[8] Prashant Vaidya, et al, "Adaptive Digital Watermarking for Copyright Protection of Digital Images in Wavelet Domain," in 2nd International Symposium on Computer Vision & Internet Published by Elsevier Procedia Computer Science 58, 2015, pp 233 - 240.

[9] Lei Chen and Jiying Zhao, "Adaptive Digital Watermarking Using RDWT and SVD," in IEEE International Symposium on Haptic, Audio and Visual Environments and Games (HAVE), 2015.

[10] L. R. Roldan, M. C. Hernández, J. Chao, M. N. Miyatake and H. P. Meana, "Watermarking-based Color Image Authentication With Detection And Recovery Capability," in IEEE Latin America Transactions, Vol. 14, No. 2, Feb. 2016, pp 1050 – 1057.

[11] Aniket Roy, Arpan Kumar Maiti, Kuntal Ghosh, "A perception based color image adaptive watermarking scheme in YCbCr space," in 2nd IEEE International Conference on Signal Processing and Integrated Networks (SPIN), 2015.

[12] Navneet Yadav, Kulbir Singh, "Transform Domain Robust Image-Adaptive Watermarking: Prevalent Techniques and Their Evaluation," in IEEE International Conference on Computing, Communication and Automation, 2015.

[13] Deepti Shukla, Nirupama Tiwari and Deepika Dubey, "Survey on Digital Watermarking Techniques," in International Journal of Signal Processing, Image Processing and Pattern Recognition Vol.9, No.1, 2016, pp.239-244.

[14] Hai Tao, et al, "Robust Image Watermarking Theories and Techniques: A Review," in Journal of Applied Research and Technology, Vol. 12, February 2014, pp 122 – 138.