Comparative Analysis of Digital Watermarking Techniques

Neha Bansal, Vinay Kumar Deolia, Atul Bansal and Pooja Pathak

Abstract In this paper various techniques used for digital watermarking such as least significant bit (LSB) technique, discrete cosine transform (DCT), discrete wavelet transform (DWT), and back propagation neural network (BPN) algorithm have been compared. These techniques are used to embed and extract a watermark of an image. The performance of these algorithms is evaluated using various parameters such as mean square error, peak signal-to-noise ratio (PSNR), and normalized correlation (NC). Parameters for each technique are compared for various noises like Gaussian noise, Poisson noise, salt-and-pepper noise, and speckle noise. Based on comparison it is suggested that BPN gives better result in terms of PSNR and NC.

Keywords Digital watermarking · Least significant bit (LSB) technique · Discrete fourier transform (DFT) · Discrete cosine transform (DCT) · Discrete wavelet transform (DWT) · Back propagation neural network (BPN) · Counter propagation neural network (CPN) · Normalized cross-correlation (NC) · Peak signal-to-noise ratio (PSNR)

1 Introduction

Digital watermarking is a method to prevent illegal copying of digital content as it can be copied and edited easily. Digital watermarking can be done in various ways. It can be done in spatial domain using least significant bit (LSB) technique. It can also be done in spectral domain using various transforms such as discrete fourier transform (DFT), discrete cosine transform (DCT), and discrete wavelet transform (DWT). Another method of digital watermarking is based on neural network.

Neha Bansal (✉) · V.K. Deolia · Atul Bansal
Department of ECE, GLA University, Mathura, India
e-mail: neha.bansal@gla.ac.in

Pooja Pathak
Department of Mathematics, GLA University, Mathura, India

S.C. Satapathy et al. (eds.), *Proceedings of the International Congress on Information and Communication Technology*, Advances in Intelligent Systems and Computing 438, DOI 10.1007/978-981-10-0767-5_13

Various types of neural network algorithm like back propagation neural network, counter propagation neural network, etc., can be used for it. This method is highly secure because in this method, watermarked image is not sent so it cannot be harmed.

2 Classification of Digital Watermarking Schemes

Various types of watermarking methods are used for the protection of digital data. Some of which are:

2.1 Spatial Domain Watermarking Technique

In spatial domain, watermarking is done in pixel domain. The pixel domain methods have main strengths that they are theoretically simple and have very less computational complexities. Embedding of the watermark into cover image is based on the operations like shifting or replacing of bits. Most commonly used spatial domain watermarking technique is least significant bit technique. In this technique, pixel values of cover image as well as watermark image are converted into binary form. The bits of watermark image replace the least significant bit of cover image and in this way, watermark can be embedded into cover image. Figure 1 shows the framework of the embedding using LSB technique.

The extraction is also very simple. Watermark data can be extracted by matching the supposed sample with the received data. At the extractor end, a zero matrix equal to the size of watermark is taken for the purpose of extraction. Each element

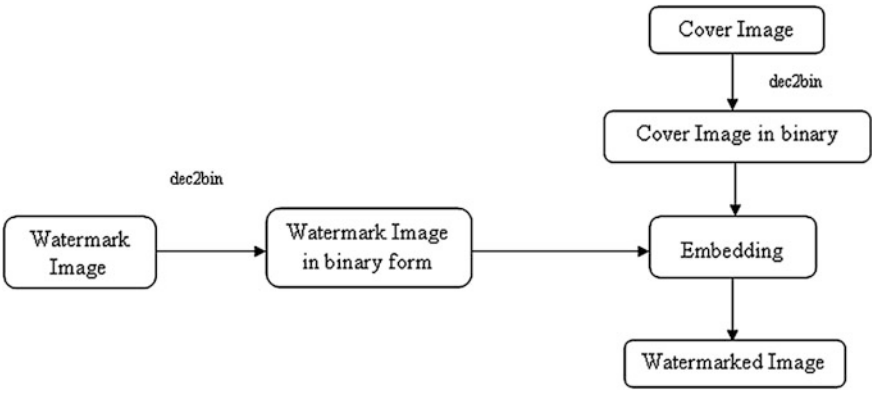

Fig. 1 Embedding of watermark using LSB technique

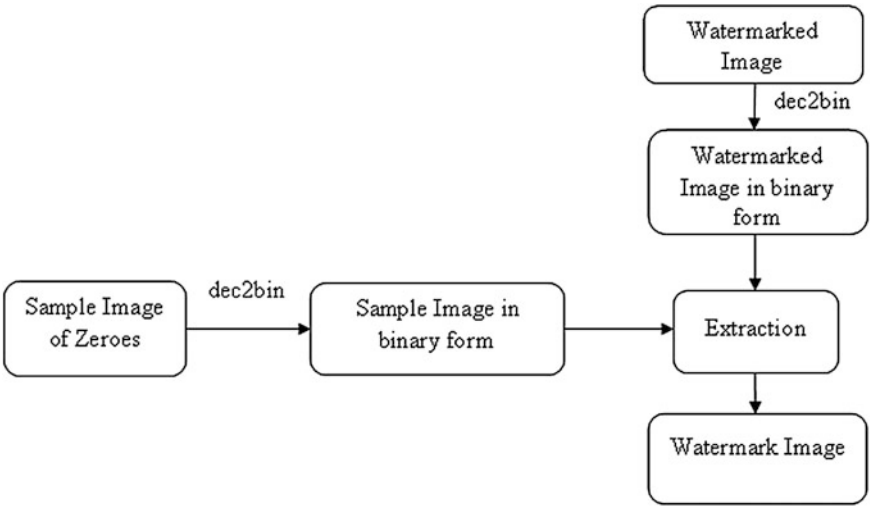

Fig. 2 Extraction of watermark using LSB technique

of zero matrix is converted into binary form as well as watermarked image pixels are also converted into binary form. The least significant bits of watermarked image are replaced by each bit of zero matrix. In this way watermark is retrieved by the extractor. Figure 2 shows the framework of the extraction using LSB technique.

In the proposed method, the cover image is of size m x n and the watermark image is of size (m × n)/8. The 8th bit of each pixel of cover image is replaced by each bit of the watermark image. The 8th bit of a binary number has least significance so its effect on the cover image is minimum. In this way watermark is embedded and watermarked image is obtained. The performance will be measured using MSE, peak signal-to-noise ratio (PSNR), and normalized correlation (NC). The process is shown in Fig. 3.

2.2 Spectral Domain Watermarking Technique

2.2.1 Watermarking Using DCT

The DCT is a very favored transform function used in digital signal processing. DCT can also be applied in pattern recognition, data compression, and image processing.

Figure 4 shows the framework of the embedding using DCT. Digital watermarking can be done by applying DCT on cover image to get transformed coefficients. If cover image coefficient is represented as C_a, W_i is the corresponding bit of

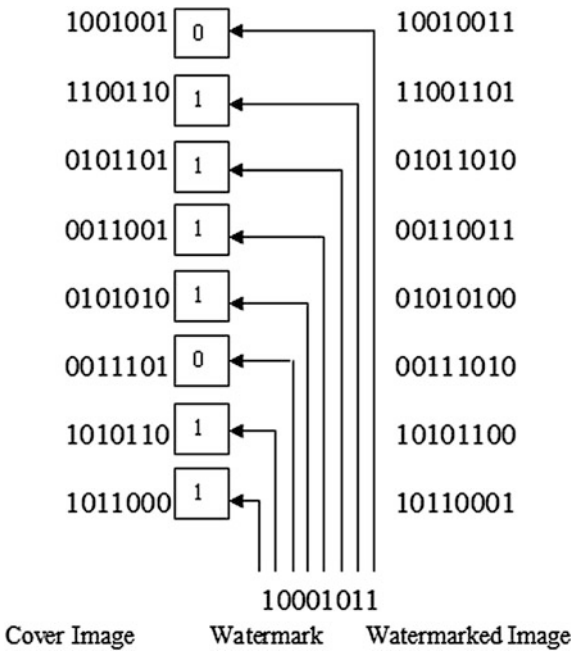

Fig. 3 Process of LSB watermarking using 8th bit

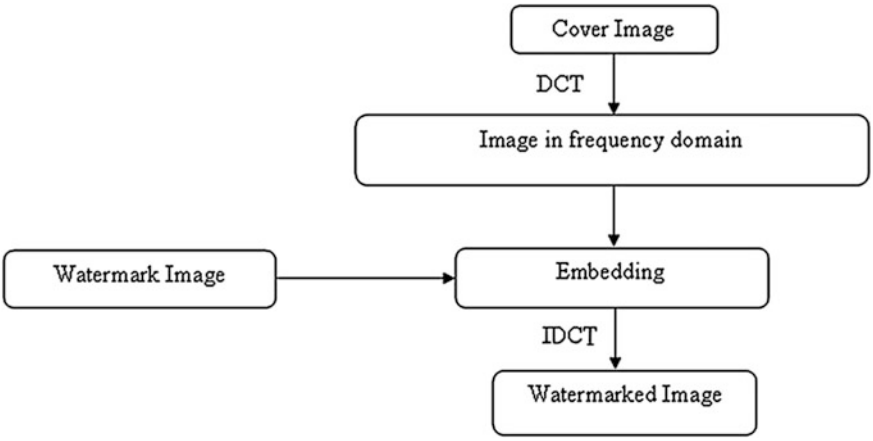

Fig. 4 Embedding of watermark using DCT

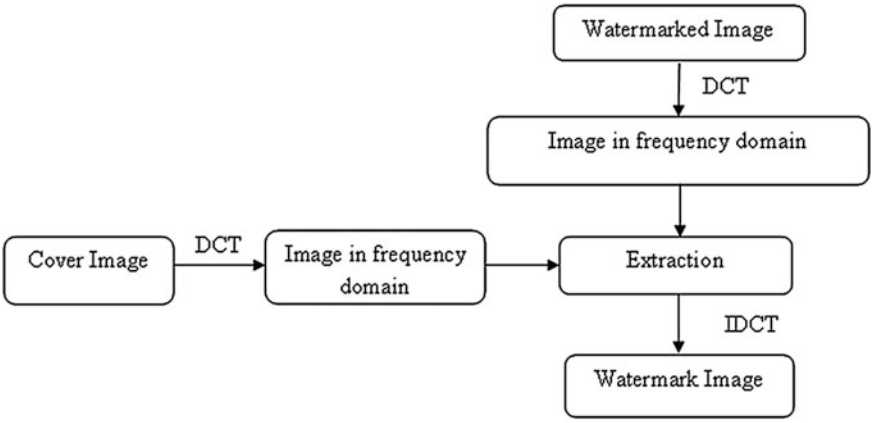

Fig. 5 Extraction of watermark using DCT

the message data, α denotes watermarking strength, and watermarked coefficient is represented as C_{aw} then coefficients are altered depending upon the stream bits of the message using the equation

$$C_{aw} = C_a(1 + \alpha W_i) \tag{1}$$

Figure 5 shows the framework of the extraction using DCT. The extraction can be done in reverse manner. The extracted image can be obtained depending upon the difference between the original DCT coefficients and the watermarked image ones. It can be obtained by the following formula:

$$W_i = \frac{1}{\alpha}(C_{aw} - C_a) \tag{2}$$

2.2.2 Watermarking Using DWT

Wavelet technique is another significant domain for watermarking. When DWT is applied to an image, it decomposes the image into four significant components which are lower resolution (LL), horizontal (HL), vertical (LH), and diagonal (HH) detail components. Figure 6 shows the framework of the watermark embedding using DWT. Watermarking using DWT can be done by applying DWT on cover image to decompose it into four parts. If cover image coefficient is represented as C_a, it is decomposed into four parts, W_i is also decomposed into four parts, α represents watermarking strength and watermarked decomposition is

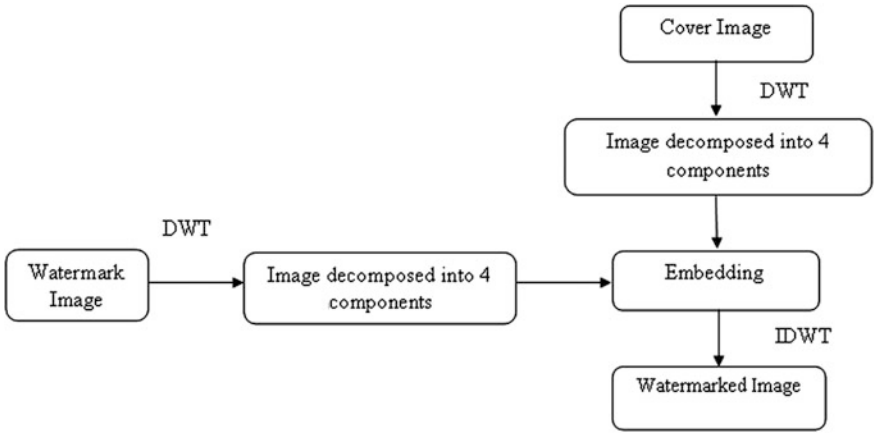

Fig. 6 Embedding of watermark using DWT

represented as C_{aw} then coefficients are altered depending upon the stream bits of the message using equation

$$C_{aw} = C_a(1 + \alpha W_i) \tag{3}$$

Figure 7 shows the framework of the extraction using DWT. The extraction can be done in reverse manner. The extraction can be done by subtracting the original

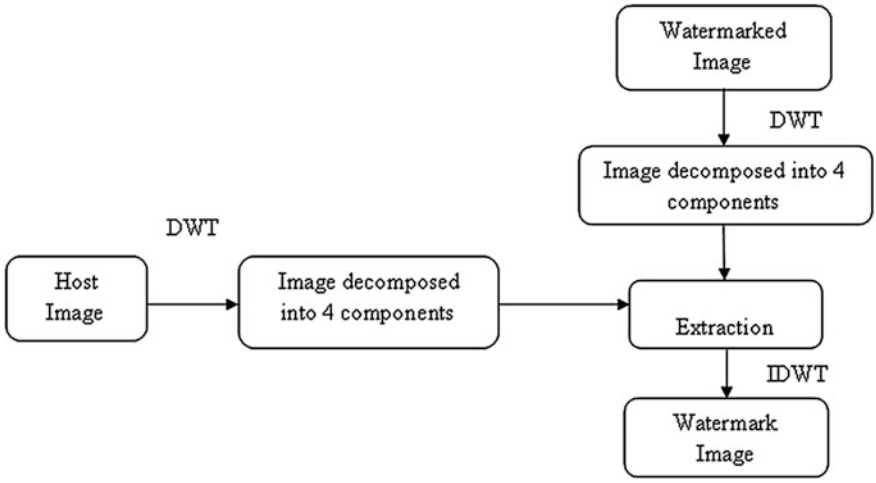

Fig. 7 Extraction of watermark using DWT

DWT coefficients from the watermarked image ones. It can be obtained by the following formula:

$$W_i = \frac{1}{\alpha}(C_{aw} - C_a) \tag{4}$$

2.2.3 Watermarking Using Back Propagation Neural Network

Digital watermarking can be done using back propagation neural network (BPN). BPN can be used to embed the watermark as well as to extract the watermark.

Embedding of watermark using BPN can be done using following steps:

- The cover image and watermark image are divided into small fragments of size 2×1.
- A BPN is taken with input layer, one hidden layer, and output layer.
- The fragments of cover image are supplied as input to the BPN and the network is trained to generate the fragments of watermark image. Weights are adjusted to produce the desired output for the given input.
- The weights are stored in a file and the cover image with the weight file is sent to the extractor.

The process of watermark embedding is shown in Fig. 8. Extraction of watermark using BPN can be done using following steps:

- At the extractor end, both files are received (weight file and cover image).
- The cover image is divided into small fragments of size 2x1.
- The weights are extracted from the weight file and BPN is reconstructed.
- With the help of fragments of cover image and trained weights, BPN gives the output same as watermark image.

The process of watermark extraction is shown in Fig. 9.

The performance of this technique is also measured for noised image. Various types of noises are used such as Gaussian noise, Poisson noise, salt-and-pepper noise, and speckle noise.

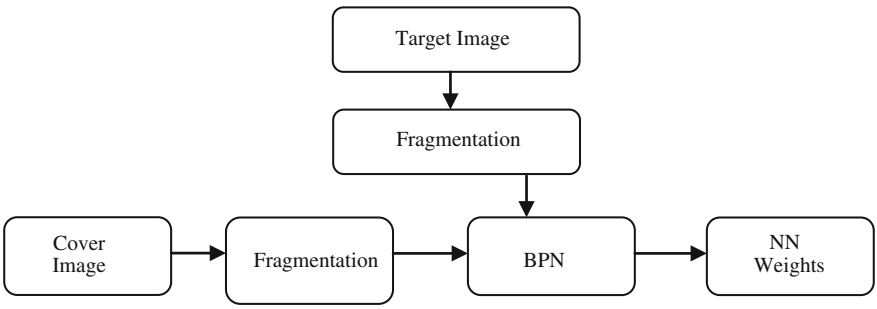

Fig. 8 Watermark embedding using BPN

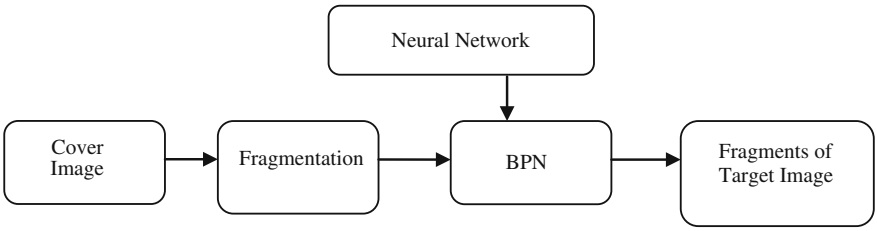

Fig. 9 Watermark extraction using BPN

3 Results

Digital watermarking can be done using various techniques. Watermark is embedded in cover image and the embedded image is sent to the receiver. PSNR and NC give the robustness of the technique. The time consumed by different techniques has been also compared in this work. The results obtained are as follows: (Tables 1, 2 and 3) (Figs. 10, 11 and 12).

Table 1 PSNR values for digital watermarking techniques (dB)

Methods	LSB in 6th bit	LSB in 7th bit	LSB in 8th bit	DCT	DWT	BPN
Without noise	137.75	151.33	165.81	109.2	59.8	129.36
Gaussian noise	46.193	46.321	46.367	66.26	44	115.35
Poisson noise	63.998	63.945	63.919	63.86	54.24	129.07
Salt-and-pepper noise	41.848	42.397	42.352	42.27	40.48	85.474
Speckle noise	47.605	47.629	47.655	47.59	43.85	129.36

Table 2 NC values for digital watermarking techniques

Methods	LSB in 6th bit	LSB in 7th bit	LSB in 8th bit	DCT	DWT	BPNN
Without noise	1	1	1	1	0.994	1
Gaussian noise	0.73	0.688	0.6918	1	0.447	1
Poisson noise	0.6388	0.7005	0.7282	1	0.834	1
Salt-and-pepper noise	0.978	0.9955	0.995	1	0.968	0.999
Speckle noise	0.6522	0.7274	0.733	1	0.741	1

Table 3 Time consumed in various digital watermarking techniques

Methods	LSB in 6th bit	LSB in 7th bit	LSB in 8th bit	DCT	DWT	BPN
Without noise	0.4695	0.4765	0.2822	1.169	1.762	947.57
Gaussian noise	0.6002	0.6115	0.5692	1.311	1.19	779.99
Poisson noise	0.6131	0.6026	0.5743	1.056	1.2	1811.5
Salt-and-pepper noise	0.5907	0.6078	0.5943	1.078	1.203	1999.8
Speckle noise	0.6078	0.5927	0.6121	1.196	1.271	750.24

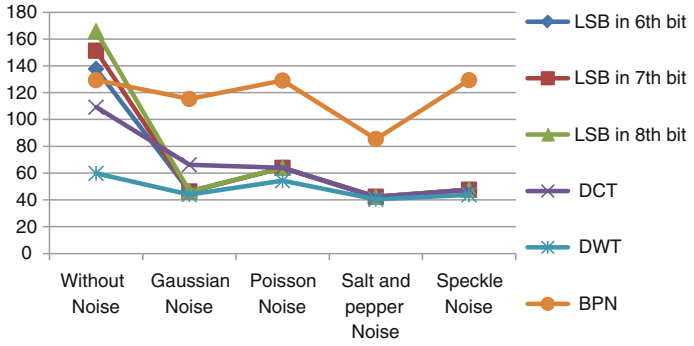

Fig. 10 Graphical representation of PSNR for the proposed technique

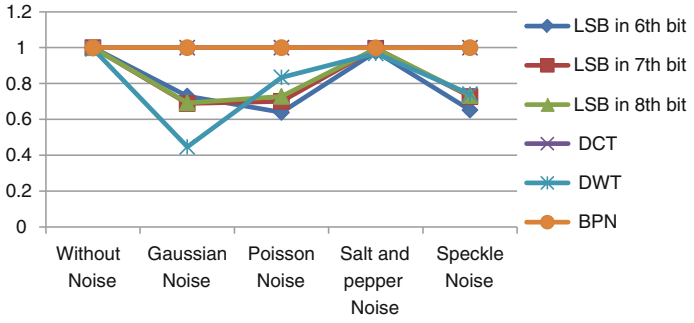

Fig. 11 Graphical representation of NC for the proposed technique

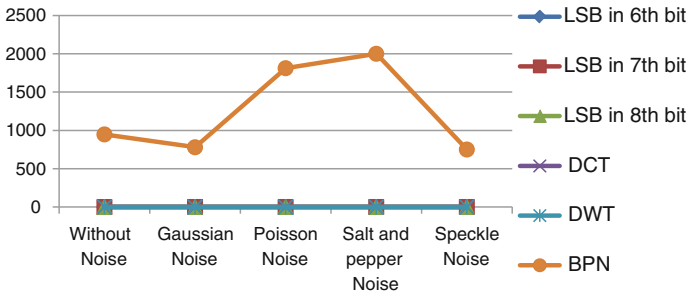

Fig. 12 Graphical representation of time consumed for the proposed technique

4 Conclusion

In this work LSB, DCT, DWT, and BPN are used to embed the watermark with cover image which is being sent to the extractor. The performance has been evaluated using PSNR and NC. On the basis of above results, it is clear that spatial domain is the easiest method but it is less secure. Watermarking using DCT and DWT is more robust. The results of watermarking using BPN are best and it is robust as well as secure technique. But the time consumed in BPN technique is higher than in other techniques.

5 Future Work

This work can be further developed using high security algorithms for embedding and extraction of watermark using full counter propagation neural network, etc.

References

1. C.Y. Chang and S.J. Su, "The Application of a Full Counterpropagation Neural Network to Image Watermarking", in Proc. of IEEE Networking, Sensing and Control, pp. 993–998, 2005.
2. Wai C. Chu, "DCT-Based Image Watermarking Using Subsampling", IEEE Trans. on multimedia, vol. 5, no. 1, pp. 34–38, March 2003.
3. Puneet Kr Sharma and Rajni, "Information security through Image Watermarking using Least Significant Bit Algorithm," Computer Science & Information Technology, vol. 2, no. 2, May 2012.
4. Gaurav Bhatnagar and Balasubramanian Raman, "A new robust reference watermarking scheme based on DWT-SVD", Elsevier Computer Standards & Interfaces, vol. 31, no. 5, September 2009, pp. 1002–1013.

5. Neha Bansal and Pooja Pathak, "A Review of Applications of Neural Network In Watermarking" In the Proc. of 7th National Conference on Advancement of Technologies-Information Systems & Computer Networks, pp. 9–12.
6. Neha Bansal, Vinay Deolia, Atul Bansal and Pooja Pathak, "Digital Image Watermarking Using Least Significant Bit Technique in Different Positions", In the Proc. of 6th International Conference on Computational Intelligence and Communication Networks, pp. 813–818, 2014.
7. Neha Bansal, Vinay Deolia, Atul Bansal and Pooja Pathak, "Comparative Analysis of LSB, DCT and DWT for Digital Watermarking", In the Proc. of the 2nd International Conference on "Computing for Sustainable Global Development", pp. 2.1–2.6, 2015.
8. Mauro Barni, Franco Bartolini, Vito Cappellini and Alessandro Piva, "A DCT-domain system for robust image watermarking," Elsevier Signal Processing 66, 1998, pp. 357–372.
9. J.J.K. O'Ruanaidh, W.J. Dowling and F.M. Boland, "Watermarking digital images for copyright protection", IEE Proceedings—Vision, Image and Signal Processing, vol. 143, no. 4, August 1996, pp. 250–256.
10. M.D. Swanson, M. Kobayashi and A.H. Tewfik, "Multimedia data-embedding and watermarking techniques", Proc. of IEEE, vol. 86, no. 6, 1998, pp. 1064–1087.