Chapter 8
Secure Multiple Watermarking Technique Using Neural Networks

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8.1 Introduction

The continuous developments in information and communication technologies (ICTs) and multimedia technology offers widespread use of multimedia contents such as images, audio and video [1]. All these technological advancements introduced a progressive change in various health care facilities such as information management, Hospital Information System (HIS), medical imaging and health social networks [1, 2]. Telemedicine is defined as use of ICTs in order to provide healthcare services when practicing doctors, patients and researchers are present in different geographical locations [3]. Although such transmission and distribution of electronic patient record (EPR) raises security related issues such as reliability, integrity, security, authenticity and confidentiality [4–7]. In recent years, the watermarking technology is a value added tools for different health data management

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issues [5, 6] and medical identity theft in healthcare applications [8–11] to involve hiding information within the cover data and the hidden information can be later recovered at the receiver side for purposes of ownership verification, unique authentication. Despite the extensive literature on wide range of applications, some researcher/scientist has been reported little work toward the development of health-oriented perspectives of watermarking [5, 6, 12–21]. Robustness, imperceptibility, capacity, computational cost and security are important benchmark parameters for general watermarking system [11]**.** Various noted researcher/scientist strive to developed different watermarking techniques for improving one or a subset of these parameters [12–15, 20, 21]. However, it is noticed that they compromise with other remaining parameters. Thus, there is need to develop effective watermarking methods that can offer good trade-off between these benchmark parameters. The proposed research/work presented in the chapter is focuses on to optimize trade-off between these benchmark parameters. Therefore, some optimization techniques are required to balance these benchmark parameters. Recently, Artificial Intelligence (AI) techniques such as genetic algorithm (GA), differential evolution (DE), neural networks (NN), Clonal selection algorithm (CSA) and particle swarm optimizer (PSO) [22–27] are used as an optimization technique to search optimal sub-bands and coefficients in transform domain to embed watermark with different scaling factors. In addition, these techniques can be used as optimization techniques to remove some round off errors when coefficients in transform domain are transformed to spatial domain.

The rest of the chapter is organized as follows. The related and recent state-of-the-art DWT based techniques are provided in Sect. 8.2. Section 8.3 provides the main contribution of the proposed work. The proposed technique is detailed in Sect. 8.4. The experimental results and brief analysis of the work is reported in Sect. 8.5. Next, our summary of the chapter is presented in Sect. 8.6

8.2 Related Work

A brief review of recent and related watermarking methods using DWT is presented below:

In [4], the authors present a multiple watermarking method using combination of DWT and SVD. Further, the method enhanced the security and robustness of the watermark information, encryption and Reed-Solomon ECC is applied to the watermark before embedding into the cover medical image. The method is robust for different attacks including the Checkmark attacks. Yen et al. [27] presents a digital watermarking using DCT and BPNN. In the embedding process, DCT has been applied on the cover image of size 256×256 and the watermark of size 32×32 is embedded into the mid frequency region of the cover. The simulation results indicated that the method is found to be robust for different attacks. Ganic and Eskicioglu [28] presents a hybrid method based on DWT and Singular Value Decomposition (SVD). In the embedding process, the singular values of all DWT cover sub-band information are modified with singular values of watermark information. The method is robust for different known attacks. Terzija et al. [29] proposed a method for improving the efficiency and robustness of the image watermarks using three different error correction codes (ECCs). Out of the three ECCs, Reed-Solomon code performs better than the BCH and Hamming code. The experimental results show that the method is robust for different attacks. However, the method unable to correct the error rates greater than 20%. A DWT-SVD based image watermarking method is presented by Lai et al. [30], where the watermark information is directly embedded into the singular vector of the cover image's DWT sub-bands. The experimental results show that the method is robust for different known attacks at acceptable visual quality of the watermarked image.

Vafaei et al. [31] proposed a blind watermarking method using DWT and Feed forward Neural Networks (FNN). In the embedding process, third level DWT applied on cover image and divides the selected sub-bands into different blocks. To enhance the robustness of the proposed method, the binary watermark information is embedded repetitively into the selected DWT coefficients. Experimental results demonstrate that the proposed method offer good visual quality of the watermarked image and robust against different kinds of signal processing attacks. Ali et al. [32] proposed a watermarking scheme based on Differential Evolution using DWT and SVD. In the embedding process, the singular vector of selected DWT sub-band of the cover is modified with binary watermark image. The proposed method claimed that it offer the solution for false positive problem as suffer by SVD. Mehto et al. [33] proposed a medical image watermarking using DWT and DCT. The watermark image contains patient information is embedded in to the medical cover image. The performance of the method is evaluated for different gain without using any attacks. Nguyen et al. [34] proposed reversible watermarking method using DWT. In this method, an authentication code is randomly generated and embedded into DWT sub-bands of each image block. The method is extensively evaluated for different kinds of attacks including tampered regions of different sizes, content tampered attack and collage attack. In addition, some important image watermarking techniques using neural networks have been proposed [35–37]. For a detailed description on these approaches, interested readers may directly refer to them.

8.3 Important Contribution of the Work

This chapter presents a hybrid approach (DWT, DCT and SVD) for multilevel watermarking of medical images using BPNN. The proposed method is based on popular transform domain techniques so their fusion makes a very attractive watermarking technique. Due to its excellent spatio-frequency localization properties, the DWT is very suitable to identify areas in the cover image where a watermark can be imperceptibly embedded [21, 38, 39]. However, DWT is shift sensitive, poor directionality information and lacks the phase information [39]. DCT has good energy compaction property. However, one of the main problems and the criticism of the

DCT is the blocking effect [39, 40]. An attractive mathematical property of SVD is that slight variations of singular values do not affect the visual quality of the cover medical image, which motivates the watermark embedding procedure to achieve better performance in terms of imperceptibility, robustness and capacity as compared to DWT, DCT and SVD applied individually. However, one of the main drawbacks of the SVD-based image watermarking is its false positive problem [39]. The false positive problem present in SVD is addressing in some reported techniques [41, 42]. The important contribution of the work is summarized below:

1. *Enhanced the capacity and security of watermarks*: In this method, multiple watermarks (text and image) are embedded simultaneously, which provides extra level of security with acceptable PSNR, BER and NC performance. For identity authentication purposes, multiple watermarks have been embedded instead of single watermark into the same cover medical image/multimedia objects simultaneously, which offer superior performance (extra level of security) in healthcare applications. However, the embedding of multiple watermarks in the same multimedia object decreases the PSNR performance and increase the computational time. Security of the Lump image watermark is enhanced by using Arnold transform before embedding into the cover. In addition, a popular lossless compression technique (arithmetic coding) is applied to symptoms watermark to compress the size of the watermark. This compression techniques can correctly recovered all bits of the symptom watermark in lossless manner. The signature watermark containing doctor's identification code for the purpose of origin authentication is embedding into the higher level DWT sub-band. In order to increase the robustness of the signature watermark and reduce the channel distortion, Hamming error correcting code is applied to the watermark before embedding into the cover.
2. *Improved the robustness of image and text watermark*: Tables 8.2, 8.3, 8.4, 8.5, 8.6 shows the effect of Back Propagation Neural Network (BPNN) [43] which offers higher robustness compared to without using the BPNN. In this neural network process, each input layer node is connected to a node from hidden layer and the hidden layer node is connected to a node in output layer. Further, the input layer is duplicated every single input and sends down to the hidden layer nodes. The hidden layer uses input values and modifies them using some weight value, this modified value is than send to the next layer (output) but it will also be modified by some weight from connection between hidden and output layer. Finally, the output layer process information received from its previous layer and produces output, which is processed by activation function. In addition, the robustness (reduce BER values) of the text watermark is also enhanced by using the Hamming ECC.
3. *Save the storage and bandwidth requirements*: Embedding patient's information in form of the multiple watermarks (image and text both) in cover images conserves transmission bandwidth and storage space requirements, and
4. The proposed method addressing the health data management issues also [6].

8.4 Proposed Algorithm

The proposed multilevel watermarking of medical images embeds multiple watermarks in the form of text and image into medical cover image. Table 8.1 shows the allocation of image and text watermarks according to robustness and capacity retirements at different DWT sub-bands. It is evident that watermarks containing important information and requiring more robustness are embedded in higher level DWT sub-bands [3, 4, 7].

In this method, multiple image and text watermarks are embedded in the medical cover image. In the embedding process, the cover medical image is decomposed into third-level DWT. Low-high frequency band (LH1) of the first level DWT is transformed by DCT and then SVD is applied to DCT coefficients. The image watermark is also transformed by DCT and SVD. The singular values of the watermark image information are embedded in the singular value of the cover medical image. The image, symptom and signature watermark is embedded in to the first (LH1), second (LH2) and third level (LL3) DWT sub-band of the cover image respectively. Further, Lump watermark is scrambled by using Arnold transform before embedding into the cover which provides the extra level of security. Moreover, the symptom and signature text watermarks are also compressed/encoded by lossless arithmetic compression technique (for embedding more information and can recovered all watermark bits in lossless manner) and Hamming error correction code (for improving the robustness and reducing the channel distortion) respectively. The compressed and encoded text watermarks are then embedded into the cover image. Results are obtained by varying the gain factor, text watermark size and the different cover image modalities. Experimental results are provided to illustrate that the proposed method is able to withstand a known attacks. The proposed algorithm has two different parts, the embedding and extraction process. Figure 8.1a, b shows the proposed method for embedding and extraction process respectively. The image watermark embedding and extraction process are given in sections 8.4.1 and 8.4.2 respectively. However, the text watermarks embedding and extraction process [29] are given in sections 8.4.3 and 8.4.4 respectively.

Table 8.1 Allocation of different watermarks according to robustness and capacity criteria at different sub-band

SN	Medical watermark	DWT sub band	Purpose of embedding
1	Signature	LL3	Contains Doctor's Identification code for the purpose of Authentication
2	Symptoms	LH2	Contains Patient's history and diagnostic reports related information for the purpose of preventing addition storage, transmission requirements and in order to increase capacity
3	Lump	LH1	Contains reference image watermark for the purpose of data integrity control

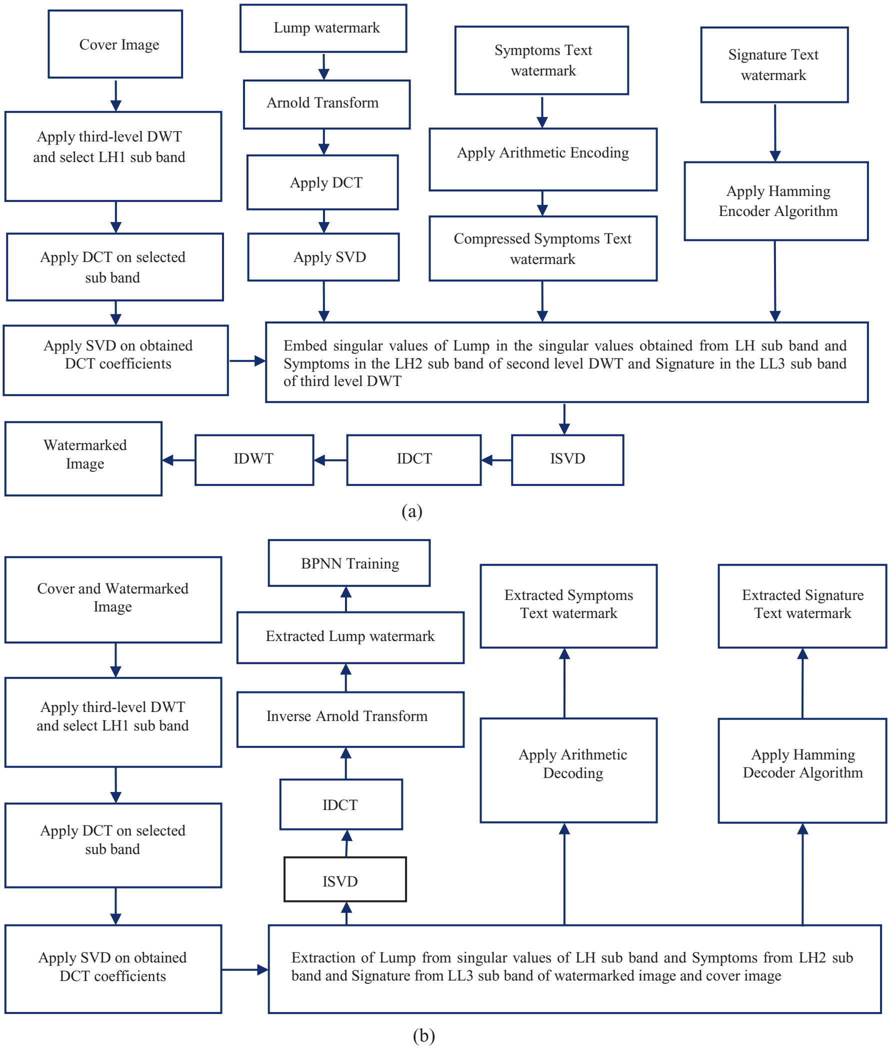


Fig. 8.1 Watermark (**a**) embedding and (**b**) extraction process

8.4.1 Embedding Algorithm for Image Watermark

1. Apply third-level DWT transform on cover image to decompose it into corresponding sub bands and select LH1 sub-band.
2. Apply DCT to the selected sub-band and then apply SVD to transformed DCT coefficients to obtain corresponding three matrices U, S and V.

$$A_c = U_c S_c V_c^T \tag{8.1}$$

3. Encrypt the Lump watermark image using Arnold Transform
4. Apply DCT on encrypted Lump watermark image and then apply SVD to DCT coefficients to obtain corresponding matrices similar to step 2.

$$A_w = U_w S_w V_w^T \tag{8.2}$$

5. Modify the singular values of LH1 sub band of cover image with the singular values of Lump.

$$S_{wat} = S_c + k \times S_w \tag{8.3}$$

Here 'k' is defined as the scaling/gain factor with which watermark images are embedded into host image.

6. Obtain modified DCT coefficients by applying Inverse Singular Value Decomposition (ISVD) using following equations.

$$A_{wat} = U_c \times S_{wat} \times V_c^T \tag{8.4}$$

7. Obtain modified LH1* sub band by applying Inverse Discrete Cosine Transform (IDCT) to modified DCT coefficients.
8. Change LH1 sub band of cover image with the modified LH1* sub band and apply Inverse Discrete Wavelet Transform (IDWT) to get watermarked image.
9. Apply attacks and noise to the watermarked image to check the robustness of the proposed algorithm.

8.4.2 Extraction Algorithm for Image Watermark

1. Apply third-level DWT transform on cover image to decompose it into corresponding sub bands and select LH1 sub band.
2. Apply DCT to the selected sub-band and then apply SVD to transformed DCT coefficients to obtain their corresponding three matrices U, S and V.

$$A_c = U_c S_c V_c^T \tag{8.5}$$

3. Apply DCT on watermark image (Lump) and then apply SVD to DCT coefficients to obtain their corresponding matrices similar to step 2.

$$A_w = U_w S_w V_w^T \tag{8.6}$$

4. Apply step 1, step 2 to watermarked image to obtain its corresponding SVD Matrices for LH1 sub band.

$$A_{wat} = U_{wat} S_{wat} V_{wat}^{T} \tag{8.7}$$

5. Obtain singular values of Lump from the singular values of LH1 sub band of watermarked image and cover image respectively by using following equation:

$$S_{w}^{*} = \left(S_{wat} - S_{c}\right) / \text{gain}\left(k\right) \tag{8.8}$$

6. Obtain extracted watermark by applying inverse singular value decomposition (ISVD) using equation (9) and then inverse discrete Cosine transform (IDCT).

$$A_{ew} = U_{w} \times S_{w}^{*} \times V_{w}^{T} \tag{8.9}$$

7. Decrypt the extracted watermark by applying inverse Arnold Transform to obtain final extracted Lump image watermark
8. BPNN is then applied to extracted watermarks to remove noise and interferences in order to improve their robustness. Figure 8.2 shows the BPNN training process.

8.4.3 Embedding Algorithm for Text Watermark

Text watermarks (Signature and Symptoms) are embedded into cover image [29] using following steps:

1. Apply third-level DWT transform on cover image to decompose it into corresponding sub bands and select LH2 and LL3 sub bands.
2. Convert the Signature text watermark into binary bits.
3. Apply Hamming encoder algorithm to binary bits of Signature text watermark and replace (0, 1) by (−1, 1) in the watermarking bits.
4. Apply Arithmetic Encoding to Symptoms text watermark and replace (0, 1) by (−1, 1) in the watermarking bits similar to step3.
5. Embed the text watermarking bits obtained from Symptoms watermark to LH2 sub band of cover image and watermarking bits obtained from Signature watermark to LL3 sub band of cover image using equation.

$$A_{i}^{'}\left(x,y\right) = A_{i}\left(x,y\right)\left(1 + k \times Wbt_{i}\right); \tag{8.10}$$

   Where, i = Signature and Symptoms text watermarks.
   $A_{i}^{'}\left(x,y\right)$ and A(x,y) are DWT coefficients before and after embedding process, Wbt_i is text watermarking bits and 'k' is the gain factor.

6. Change LH2 and LL3 sub bands of cover image with the modified $LH2^*$ and $LL3^*$ sub band and apply IDWT to get watermarked image.

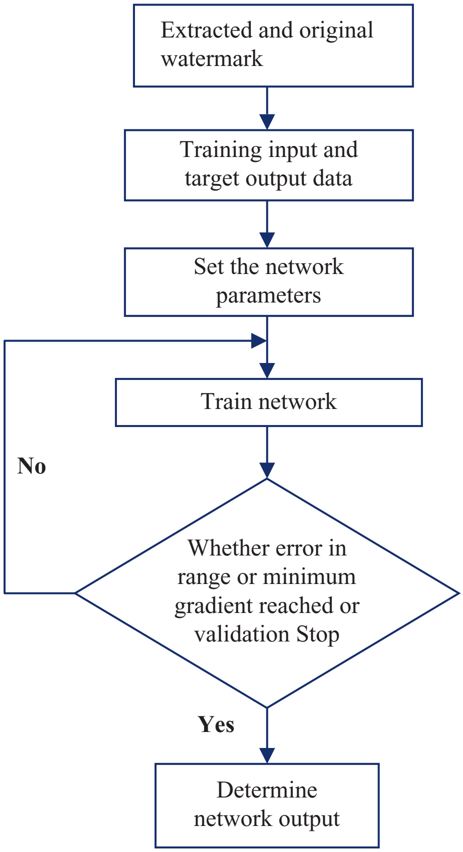


Fig. 8.2 BPNN training process [39]

8.4.4 Extraction Algorithm for Text Watermark

Text watermarks (Signature and Symptoms) are extracted [29] from watermarked image using following steps: -

1. Apply third-level DWT transform on cover image to decompose it into corresponding sub bands and select LH2 and LL3 sub bands.
2. Apply third-level DWT transform on watermarked image to decompose it into corresponding sub bands and select $LH2^*$ and $LL3^*$ sub bands.
3. Extract watermark bits of Signature text watermark form LL3 sub band of cover image and $LL3^*$ sub band of watermarked image and Symptoms text watermark form LH2 sub band of cover image and $LH2^*$ sub band of watermarked image using equation

$$Wbt_i' = \frac{A_i'(x,y) - A_i(x,y)}{k^* A_i(x,y)}; i = \text{extracted symptoms } \textit{and} \text{ signature watermark} \quad (8.11)$$

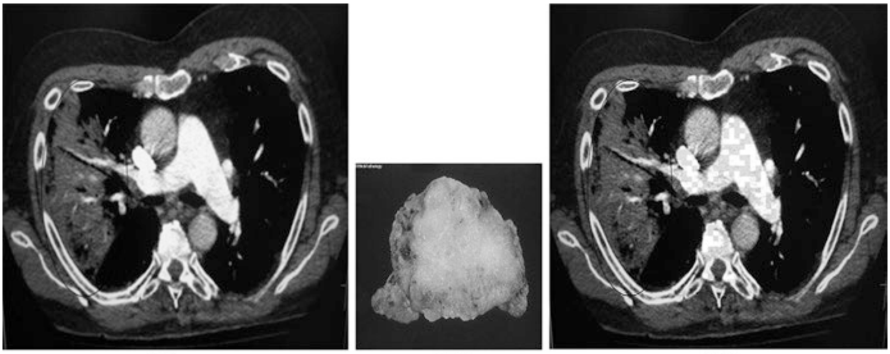
$A'(x, y)$ and $A(x,y)$ are DWT coefficients of cover and watermarked image respectively, Wbt_i' is extracted text watermarking bits and k is the gain factor.

4. Apply arithmetic decoding process to obtained watermark bits of symptoms watermark and convert watermark bits into text to obtain symptoms text watermark.
5. Apply Hamming decoder algorithm to obtained watermark bits of Signature watermark and convert watermark bits into text to obtain signature text watermark.

8.5 Experimental Results and Performance Analysis

The performance of the combined DWT-DCT-SVD watermarking algorithm has been evaluated in terms of quality of the watermarked image (PSNR), bit error rate (BER) of text watermarks and robustness of the watermarked image (NC) using BPNN. The gray-scale medical CT-scan image of size 512×512 as cover image, the Lump image of size 256×256 is considered as image watermark. For the healthcare applications security of the watermark has become an important factor. The security of the image watermark is enhanced by using Arnold transform is applied before embedding in to the cover. Signature and symptoms watermarks are considered as text watermark of size 190 characters. Signature watermark contains the doctor's signature/identification code and the symptoms watermark contains the patient diagnostic information. Robustness performance of the image watermark is improved by applying the Back Propagation Neural Network (BPNN). In order to reduce the BER performance of the proposed method, error correcting Hamming code (ECC) is applied to the ASCII representation of the signature watermark before embedding into the cover. In addition, lossless encoding method (arithmetic coding) is applied on the symptom watermark which can be correctly retrieving the diagnostic information of the patient. Strength of watermarks is varied by varying the gain factor in the proposed algorithm. For testing the robustness of the extracted watermarks (both image and text) and visual quality of watermarked cover medical image MATLAB is used. Figure 8.3a–c shows the cover CT-scan image, Lump image watermark and watermarked images respectively. Figure 8.4 shows the Signature and Symptoms text watermarks.

Figure 8.5a, b shows the extracted watermarks with and without using the BPNN training respectively. The PSNR, BER and NC performance of the proposed method is shown in Tables 8.2, 8.3, 8.4, 8.5, 8.6. In Table 8.2, the PSNR and

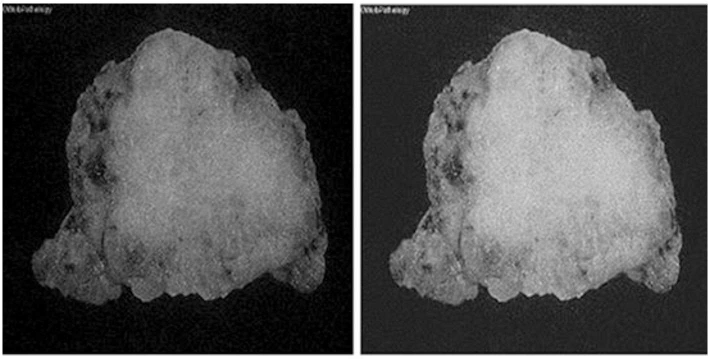


(a) (b) (c)

Fig. 8.3 (**a**) CTscan cover image (**b**) lump image watermark (**c**) watermarked image

Doctor's Signature/ID: BXBPS4999S1
Diagnostic Information
Hospital Code: JUITWAKNAGHAT
Patient No: 200_Ward_ABC
Symptoms: c/c Lump in right barest_No fever history_Pain in right shoulder_No history of retraction and discharge from Hospital_Other reports_MammographNo 1568_FNAC39_B+_SOLAN

Fig. 8.4 Signature and Symptoms text watermarks



(a) (b)

Fig. 8.5 Extracted Lump watermark (**a**) without and (**b**) with BPNN training

Table 8.2 PSNR, NC and BER performance of the proposed method at different gain

SN	Gain factor	PSNR (dB)	BER (Text Watermark)		NC values	
			Signature	Symptoms	Without BPNN	With BPNN
1	0.01	43.88	0	0.2174	0.9344	0.9547
2	0.02	41.22	0	0.1087	0.9764	0.9844
3	0.05	36.53	0	0	0.9846	0.9889
4	0.08	33.59	0	0	0.9861	0.9888
5	0.1	32.09	0	0	0.9852	0.9875
6	0.12	30.85	0	0	0.9853	0.9872
7	0.15	29.33	0	0	0.9849	0.9864
8	0.2	27.29	0	0	0.9851	0.9866

Table 8.3 PSNR, NC and BER performance for different no of characters in Symptoms watermark at different gain

SN	Number of characters	Gain factor	PSNR (dB)	BER		NC	
				Signature	Symptoms	Without BPNN	With BPNN
1	50	0.01	43.95	0	0.4202	0.9363	0.9563
		0.05	36.54	0	0	0.9846	0.9889
		0.1	32.12	0	0.4202	0.9853	0.9875
2	100	0.01	43.93	0	0.2110	0.9378	0.9573
		0.05	36.52	0	0	0.9846	0.9888
		0.1	32.10	0	0.2110	0.9851	0.9874
3	150	0.01	43.92	0	0	0.9356	0.9556
		0.05	36.51	0	0	0.9845	0.9887
		0.1	32.11	0	0	0.9854	0.9877
4	200	0.01	43.89	0	0.1370	0.9339	0.9541
		0.05	36.52	0	0	0.9847	0.9888
		0.1	32.09	0	0	0.9853	0.9877

Table 8.4 PSNR, NC and BER performance for different cover images at gain = 0.08

SN	Cover image	PSNR (dB)	BER (Text Watermark)		NC	
			Signature	Symptoms	Without BPNN	With BPNN
1	Brain	33.55	0	0	0.9745	0.9825
2	Mammography	32.94	0	0.1087	0.9474	0.9638
3	Ultrasound	34.34	0	0.4348	0.9642	0.9770
4	Lena	32.93	0	0	0.9795	0.9855
5	MRI	34.33	0	0	0.9869	0.9888
6	Mandrill	31.54	0	0	0.9845	0.9849

Table 8.5 PSNR and NC and BER performance for different text watermark size at gain 0.08

SN	Text watermark size (in characters)		PSNR (dB)	BER		NC	
	Signature	Symptoms		Signature	Symptoms	With BPNN	Without BPNN
1	12	10	33.62	0	0	0.9860	0.9886
2	12	20	33.62	0	0	0.9861	0.9887
3	12	50	33.60	0	0	0.9860	0.9887
4	12	75	33.60	0	0	0.9862	0.9888
5	12	100	33.59	0	0	0.9861	0.9889
6	12	150	33.61	0	0	0.9861	0.9886
7	12	200	33.61	0	0	0.9861	0.9887

Table 8.6 BER and NC performance of the proposed method for different attacks at gain = 0.08

SN	Attacks	BER		NC	
		Signature	Symptoms	With BPNN	Without BPNN
1	JPEG 10	0	0.1087	0.2081	0.3120
2	JPEG 30	0	0	0.9733	0.9803
3	JPEG 60	0	0	0.9679	0.9703
4	JPEG 80	0	0	0.9812	0.9871
5	JPEG 100	0	0	0.9860	0.9886
6	Salt & Peppers (density = 0.02)	0	0.2031	0.6926	0.7013
7	Salt & Peppers (density = 0.01)	0	0	0.7569	0.7747
8	Salt & Peppers (density = 0.001)	0	0	0.9604	0.9658
9	Gaussian(Mean = 0.01,Variance = 0.002)	0	0.2174	0.8365	0.8748
10	Gaussian (Mean = 0, Variance = 0.001)	0	0	0.9307	0.9466
11	Gaussian (Mean = 0.01,Variance = 0.0005)	0	0	0.9741	0.9761
12	Average filtering	0	0.1087	0.9824	0.9869
13	Low pass filtering	0	0.1087	0.9852	0.9889
14	Median filtering	0	0.2237	0.0025	0.0123
15	Speckle (Variance = 0.02)	0.1119	28.57	0.8286	0.8673
16	Speckle (Variance = 0.01)	0.1119	10.7143	0.9024	0.9286
17	Speckle (Variance = 0.005)	0	0	0.9860	0.9886
18	Rotation (2°)	0.3356	2.3810	0.4022	0.4442
19	Crop (6.25%)	0.4474	47.619	0.8691	0.9059
20	Resize (512-410-512)	0	0.3356	0.9177	0.9377
21	JPEG80 + Gaussian(M = 0.01,V = 0.002)	0	0.1119	0.8135	0.8558
22	JPEG80 + Salt & Peppers (d = 0.002)	0	0	0.9074	0.9312
23	Gaussian(M = 0.01,V = 0.002) + Speckle (V = 0.005)	0	0.2237	0.7901	0.8276
24	Salt & Peppers(d = 0.002) + Speckle (V = 0.005)	0.2237	1.1905	0.7947	0.8328
25	JPEG80 + Speckle (V = 0.005)	0	0.2237	0.9585	0.9645

NC performance of the proposed method has been evaluated without any noise attack. Without using the BPNN, the maximum PSNR value is 43.88 dB and NC value is 0.9344 at gain factor = 0.01. However, the NC value is obtained as 0.9547 with BPNN at the same gain. With BPNN, the maximum NC value is obtained as 0.9888 at gain factor = 0.08. However, the NC value has been obtained as 0.9861 without using the BPNN at same gain factor.

The BER value for signature watermark is ‘0’ at all considered gain factors. However, BER value of the Symptoms watermark is 0.2174 and 0.1087 for gain factors 0.01 and 0.02 respectively. Referring Table 8.2, we found that larger the gain factor, stronger the robustness and smaller the gain factor, better the visual

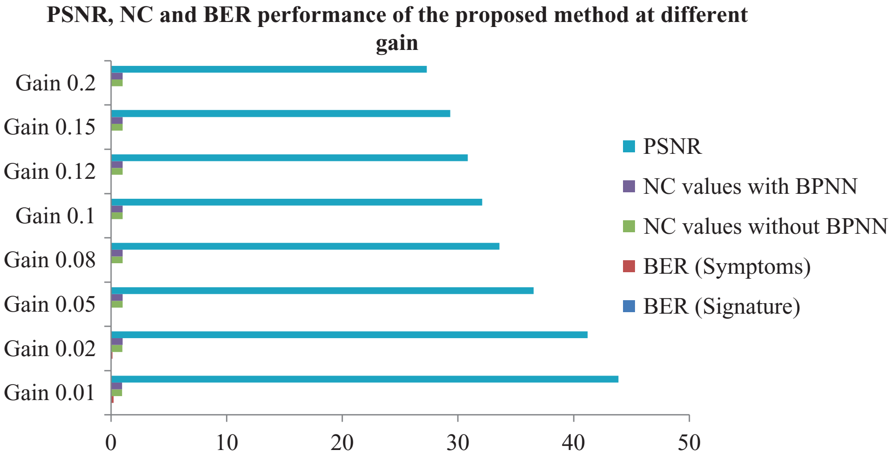


Fig. 8.6 PSNR, NC and BER performance of the proposed method at different gain factor

quality of the watermarked image. The graphical representation of Table 8.2 is shown in Fig. 8.6.

The gain factor '0.08' is considered for the experimental purpose in Tables 8.3, 8.4, 8.5, 8.6. Table 8.3 shows the PSNR, BER and NC (with and without using BPNN) performance of the proposed method for different size of text watermarks. The maximum PSNR value is obtained at gain factor 0.01, which is 43.95 dB. However, the NC value obtained is 0.9363 (without using BPNN) for 50 characters of Symptoms watermark at the same gain factor. Refereeing this table, the maximum NC value is 0.9889 (with BPNN) at gain factor 0.05 for 50 characters of Symptoms watermark. The BER value of the signature watermark is '0' at all chosen gain factors. However, the BER value is 0.4202 for the Symptoms watermark at gain = 0.01. The maximum BER value is 0.4202, which can be recovered all the bits at higher gain value.

Table 8.4 shows the PSNR, BER and NC (with and without using BPNN) performance of the proposed method for six different cover images. With BPNN, the highest NC values (0.9888) have been obtained with MRI image at gain = 0.08 for Lump image. However the minimum NC value is 0.9638 for Mammography image at the same gain. Referencing this Table, the highest BER value has been obtained for Ultrasound image, which is 0.4348. However, the minimum BER value is '0' for all other cover images except the Mammography and Ultrasound images. Figure 8.7 shows the graphical representation of Table 8.4. Table 8.5 shows the PSNR, BER and NC performance of proposed algorithm for different size of the symptoms watermark. In this table, the size of the Signature watermark is fixed and the size of Symptoms watermark is varied. Referring this table, the BER value is found to be '0' for all different size of the symptoms watermark. Figure 8.8 show the graphical representation of Table 8.5. Table 8.6 shows the BER and NC performance of the proposed method for different attacks [11].

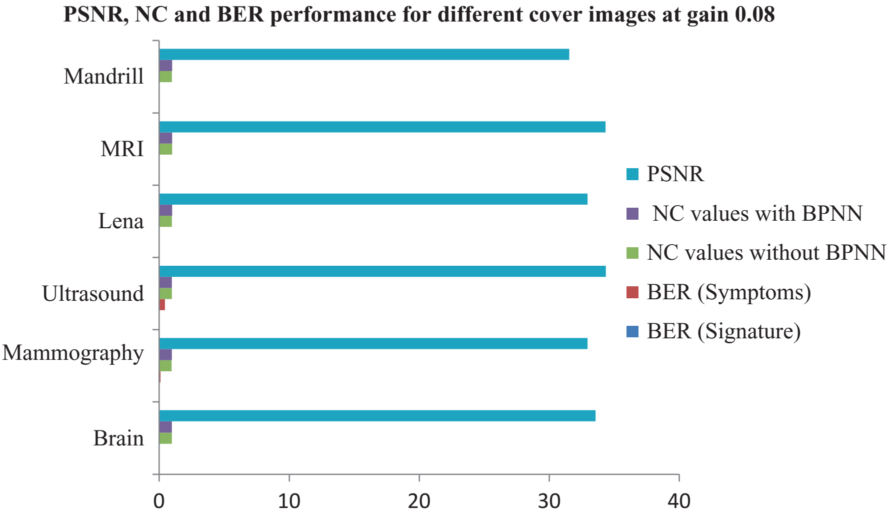


Fig. 8.7 PSNR, NC and BER performance of the proposed method for different cover image

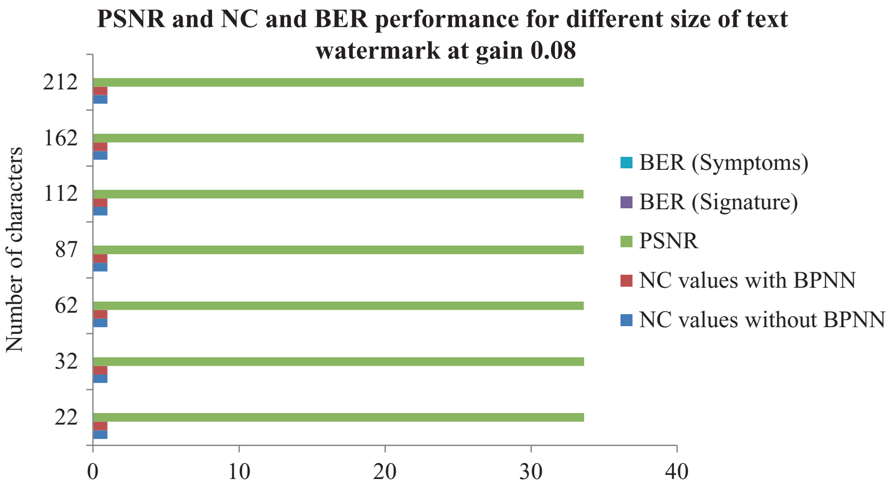


Fig. 8.8 PSNR, NC and BER performance of the proposed method for different size of text watermark

Without BPNN, the highest NC value has been obtained as 0.9852 for Gaussian low pass filtering. However, the lowest NC is 0.0025 for JPEG (QF = 10) attack. With BPNN, the highest NC value has been obtained as 0.9889 for Gaussian low pass filtering. However, the lowest NC is 0.0123 for Median filtering attack. Refereeing this table, the highest BER of Symptoms and Signature watermark is

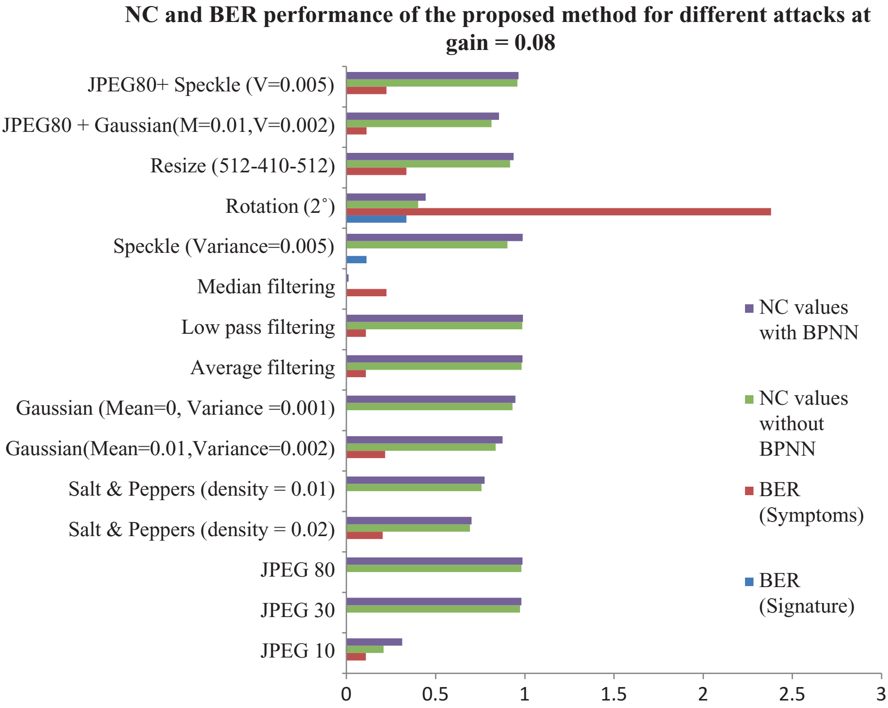


Fig. 8.9 NC and BER performance of the proposed method for known attacks

Table 8.7 Comparison results under NC value

SN	Attacks	Singh et al. [12]	Ganic et al. [28]	Proposed method
1.	JPEG 30	–	0.141	0.9787
2.	Resize (512-256-512)	–	−0.211	0.7902
3.	Gaussian noise (Mean = 0, variance = 0.3)	–	0.271	0.6583
4.	Gaussian noise (Mean = 0, variance = 0.5)	0.6565	–	0.6576
5.	Gaussian noise (Mean = 0, variance = 0.001)	0.9365	–	0.9466
6.	Salt & Peppers (density = 0.5)	0.6069	–	0.6587
7.	Salt & Peppers (density = 0.5)	0.7552	–	0.7747
8.	Gaussian LPF (Standard Deviation = 0.6)	0.9343	–	0.9883
9.	Histogram Equilization	0.569	0.716	0.9404

Table 8.8 Subjective measure of the watermarked image quality at different gain factor

Gain factors	Quality of the watermarked image
0.01	Excellent visual quality of the watermarked image
0.05	Very good visual quality of the watermarked image
0.1	Good visual quality of the watermarked image
0.15	Average/acceptable visual quality of the watermarked image
0.2	Poor visual quality of the watermarked image
0.5	Very poor visual quality of the watermarked image

47.619% and 0.4474% for Crop attack respectively. However, the minimum BER value is '0'. Figure 8.9 show the graphical representation of Table 8.6.

Table 8.7 show the NC performance of the proposed method is compared with other reported techniques [12, 28]. The maximum NC value obtained by the Singh et al. [12] and Ganic et al. [28] is 0.9365 and 0.716 respectively. However, the maximum NC value obtained by the proposed method is 0.9883. Referring Table 8.7 it is established that the proposed method obtained NC value range from 0.6576 to 0.9883. However, NC value range as obtained by the Singh et al. from 0.569 to 0.9365 and Ganic et al. from −0.211 to 0.716. The proposed method offer higher robustness than the other two reported techniques. Finally, the quality of the watermarked image is evaluated by the subjective technique also [12] in Table 8.8. Six different persons are involved who have to vote for the quality of a medium in a controlled test environment. This can be done by simply providing a distorted medium of which the quality has to be evaluated by the subject. Referring Table 8.8 it is established that the quality of the watermarked images is acceptable for diagnosis at all the chosen gain factors except the gain factor = 0.2 and 0.5, which shows the poor/very poor visual quality of the watermarked image. Based on the above discussion, the proposed method highly depends on the gain factors, size if the image and text watermark and different noise variations.

8.6 Summary

In this chapter, a novel method for multiple watermarking based on DWT, DCT and SVD has been presented using Back Propagation Neural Network. The suggested method considered gray scale images for the experimental purpose. However, the watermark embedding into color image provides greater space against the watermark embedding into gray scale image. The performance of the watermarking system will greatly depends on the choice of color space and selection of embedding color channel. The main properties of the proposed work is identified as follows:

1. The fusion of DWT, DCT and SVD offer better performance in terms of imperceptibility, robustness and capacity as compared to DWT, DCT and SVD applied individually.
2. Embedding more than one watermark within the cover image reduces the storage capacity and the bandwidth requirements. The storage and bandwidth requirements are very important in medical applications.
3. For enhancing the robustness of the image watermark, BPNN is applied to the extracted watermark which gives the higher NC values compared to without using the BPNN.
4. Security and confidentiality are provided by scrambling the Lump watermark using Arnold transforms before embedding into the cover.
5. Lossless arithmetic compression is applieded to Symptoms watermark before embedding in to the cover for the bit compactness. The lossless compression techniques is also preffered in medical applications in which every bit information is preserved before and after the compression process.
6. To increase the robustness of the signature watermark and reduce the channel distortion, Hamming error correcting code is applied to the watermark before embedding into the cover, and
7. Finally, the visual quality of the watermarked image is evaluated by the subjective method also. Therefore, proposed method provides a valuable solution for the prevention of patient identity theft in healthcare applications such as tele-ophthalmology, tele-medicine, tele-diagnosis and tele-consultancy etc.

In future, the performance of the suggested wavelet based image watermarking method can be extended for their application to video watermarking.

References

1. H. Nyeem, W. Boles, C. Boyd, A review of medical image watermarking requirements for teleradiology. J. Digit. Imaging **26**(2), 326–343 (2013)
2. A.M. Elmisery, S. Rho, D. Botvich, A distributed collaborative platform for personal health profiles in patient-driven health social network. IJDSN Hindawi Publ. Corp. **2015**, 1–12 (2015)
3. A.K. Singh, B. Kumar, M. Dave, A. Mohan, Multiple watermarking on medical images using selective DWT coefficients. J. Med. Imaging Health Inf. **5**(3), 607–614 (2015)
4. A.K. Singh, M. Dave, A. Mohan, Robust and secure multiple watermarking in wavelet domain. A special issue on advanced signal processing technologies and systems for healthcare applications (ASPTSHA). J. Med. Imaging Health Inf. **5**(2), 406–414 (2015)
5. A. Giakoumaki, S. Pavlopoulos, D. Koutsouris, Secure and efficient health data management through multiple watermarking on medical images. Med. Biol. Eng. Comput. **44**, 619–631 (2006)
6. A. Giakoumaki, S. Pavlopoulos, D. Koutsouris, Multiple image watermarking applied to health information management. IEEE Trans. Inf. Technol. Biomed. **10**, 722–732 (2006)
7. A.K. Singh, Improved hybrid technique for robust and imperceptible multiple watermarking using digital images. Multimedia Tools Appl. **76**(6), 8881–8900 (2017)
8. M. Terry, Medical identity theft and telemedicine security. Telemed. e-Health **15**(10), 928–932 (2009)

9. D. Bowman, http://www.fiercehealthit.com/story/researchers-use-digital-watermarks-protect-medical-images (2012)
10. M. Ollove, www.usatoday.com/story/.../stateline-identity-thefts-medical.../5279351 (2014)
11. A.K. Singh, B. Kumar, M. Dave, S.P. Ghrera, A. Mohan, Digital image watermarking: techniques and emerging applications, in *Handbook of Research on Modern Cryptographic Solutions for Computer and Cyber Security* (IGI Global, Hershey, 2016), pp. 246–272
12. A.K. Singh, M. Dave, A. Mohan, Hybrid technique for robust and imperceptible multiple watermarking using medical images. J. Multimedia Tools Appl. **75**(14), 8381–8401 (2016)
13. A. Kannammal, S. Subha Rani, Two level security for medical images using watermarking/encryption algorithms. Int. J. Imaging Syst. Technol. **24**(1), 111–120 (2014)
14. K. Pal, G. Ghosh, M. Bhattacharya, Biomedical image watermarking in wavelet domain for data integrity using bit majority algorithm and multiple copies of hidden information. Am. J. Biomed. Eng. **2**(2), 29–37 (2012)
15. A.K. Singh, M. Dave, A. Mohan, Multilevel encrypted text watermarking on medical images using spread-spectrum in DWT domain. Wireless Personal Commun.: Int. J. **83**(3), 2133–2150 (2015)
16. B. Kumar, H.V. Singh, S.P. Singh, A. Mohan, Secure spread-spectrum watermarking for telemedicine applications. J. Inf. Secur. **2**, 91–98 (2011)
17. B. Kumar, A. Anand, S.P. Singh, A. Mohan, High capacity spread-spectrum watermarking for telemedicine applications. World Acad. Sci. Eng. Technol. **5**, 62–66 (2011)
18. I.J. Cox, J. Kilian, L.F. Thomson, S. Talal, Secure spread spectrum watermarking for multimedia. IEEE Trans. Image Process. **6**(12), 1673–1687 (1997)
19. A.K. Singh, B. Kumar, M. Dave, A. Mohan, Robust and imperceptible spread-spectrum watermarking for telemedicine applications. Proc. Natl. Acad. Sci., India, Sect. A: Phys. Sci. **85**(2), 295–301 (2015)
20. A. Sharma, A.K. Singh, S.P. Ghrera, Robust and secure multiple watermarking technique for medical images. Wirel. Pers. Commun. **92**(4), 1611–1624 (2017)
21. R. Pandey, A.K. Singh, B. Kumar, A. Mohan, Iris based secure NROI multiple eye image watermarking for teleophthalmology. Multimedia Tools Appl. **75**(22), 14381–14397 (2016)
22. Z. Wei, H. Li, J. Dai, S. Wang, Image watermarking based on genetic algorithm, in IEEE International Conference on Multimedia and Expo, Toronto, ON, pp. 1117–1120, 2006
23. V. Aslantas, A.L. Dogan, S. Ozturk, DWT-SVD based image watermarking using particle swarm optimizer, in IEEE International Conference on Multimedia and Expo, Hannover, pp. 241–244, 2008
24. V. Aslantas, S. Ozer, S. Ozturk, Improving the performance of DCT-based fragile watermarking using intelligent optimization algorithms. Opt. Commun. **282**(14), 2806–2817 (2009)
25. V. Aslantas, An optimal robust digital image watermarking based on SVD using differential evolution algorithm. Opt. Commun. **282**(5), 769–777 (2009)
26. A.R.N. Nilchi, A. Taheri, A new robust digital image watermarking technique based on the discrete cosine transformation and neural network, in International Symposium on Biometrics and Security Technologies, Islamabad, pp. 1–7, 2008
27. C.T. Yen, Y.J. Huang, Frequency domain digital watermark recognition using image code sequences with a back-propagation neural network, Multimedia Tools Appl. **75**(16), 9745–9755 (2016)
28. E. Ganic, A.M. Eskicioglu, Robust DWT-SVD domain image watermarking: embedding data in all frequencies, in Proceedings of the 2004 Workshop on Multimedia and Security, ACM, pp. 166–174, 2004
29. N. Terzjia, M. Repges, K. Luck, W. Geisselhardt, Digital image watermarking using discrete wavelet transform: performance comparison of error correction codes, in International Association of Science and Technology for Development, 2002
30. C.-C. Lai, C.-C. Tsai, Digital image watermarking using discrete wavelet transform and singular value decomposition. IEEE Trans. Instrum. Meas. **59**(11), 3060–3063 (2010)

31. M. Vafaei, H. Mahdavi-Nasab, H. Pourghassem, A new robust blind watermarking method based on neural networks in wavelet transform domain. World Appl. Sci. J. **22**(11), 1572–1580 (2013)
32. M. Ali, C. WookAhn, P. Siarry, Differential evolution algorithm for the selection of optimal scaling factors in image watermarking. Special issue on advances in evolutionary optimization based image processing. Eng. Appl. Artif. Intell. **31**, 15–26 (2014)
33. A. Mehto, N. Mehra, Adaptive lossless medical image watermarking algorithm based on DCT & DWT. Proc. Computer Sci. **78**, 88–94 (2016)
34. T.S. Nguyen, C.C. Chang, X.Q. Yang, A reversible image authentication scheme based on fragile watermarking in discrete wavelet transform domain. AEU-Int. J. Electron. Commun. **70**(8), 1055–1061 (2016)
35. M. Shi-chun, L. Ren-hou, D. Hong-mei, W. Yun-kuan, Decision of image watermarking strength based on artificial neural-networks, in Proceedings of the 9th International Conference on Neural Information Processing, pp. 2430–2434, 2002
36. Y. Qun-ting, G. Tie-gang, L. Fan, A novel robust watermarking scheme based on neural network, in International Conference on Intelligent Computing and Integrated Systems (ICISS), IEEE, pp. 71–75, 2010
37. N. Mohananthini, G. Yamuna, Watermarking for images using wavelet domain in Back-Propagation neural network, in Advances in Engineering, Science and Management, pp. 100–105, 2012
38. M. Barni, F. Bartolini, Improved wavelet-based watermarking through pixel-wise masking. IEEE Trans. Image Process. **10**(5), 783–791 (2001)
39. A. Zear, A.K. Singh, P. Kumar, Multiple watermarking for healthcare applications. J. Intell. Syst. (2016). doi: 10.1515/jisys-2016-0036
40. B. Zeng, Reduction of blocking effect in DCT-coded images using zero-masking techniques. Signal Process. **79**(2), 205–211 (1999)
41. J.-M. Guo, H. Prasetyo, False-positive-free SVD-based image watermarking. J. Vis. Commun. Image Represent. **25**(5), 1149–1163 (2014)
42. F.N. Thakkar, V.K. Srivastava, A blind medical image watermarking: DWT-SVD based robust and secure approach for telemedicine applications. Multimedia Tools Appl. **76**(3), 3669–3697 (2017)
43. M. Cilimkovic, Neural networks and back propagation algorithm, Master Thesis, Institute of Technology, Ireland, 2013