International Journal of Engineering & Technology, 7 (3.27) (2018) 265-269

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Mean Square Error Optimization to Authenticate Multi-Modality Medical Images in Wavelet Domain

S.K. Jayanthi[1*], K. Sridevi[2]

[1]*Associate Professor and Head, Department of Computer Science, Vellalar College for Women, Erode, Tamilnadu, India.*
[2]*Research Scholar, Department of Computer Science, Vellalar College for Women, Erode, Tamilnadu, India.*
E-mail:srivisva14@gmail.com
**Corresponding author E-mail:jayanthiskp@gmail.com*

Abstract

Medical image watermarking which hides patient's information in the medical image ensures its imperceptibility and at the same time provides robustness to the information that is embedded. Current research scenario embeds the authenticated message as watermark in the frequency domain to get watermarked image which has most of its values as real numbers. Since pixel intensity values must be represented as integers, the watermarked image is converted into spatial domain where the rounding error problem occurs and the embedded message cannot be extracted to prove its authenticity. In proposed work, a new watermarking scheme in Discrete Wavelet Transform (DWT) domain based on Genetic Algorithm (GA) is implemented to ensure correct retrieval of embedded watermark by optimizing Mean Square Error (MSE) measure.

Keywords: *Authentication, genetic algorithm, imperceptibility, robustness, rounding error.*

1. Introduction

In recent decades with the rapid development of biomedical engineering, digital medical images are increasingly important in hospitals and clinical environment. Concomitantly, traversing medical images between hospitals in complicated network protocol leads to image compression and security problems [7]. Many digital watermarking techniques have been proposed to solve the problem by hiding an invisible watermark in an image to prove the authentication of the image. Authenticity of a medical image proves that the image is from right source and possesses reliability.

Watermarks like hospital logo, doctor's signatures, patient identification code and patient history act as an authentication message [1]. These messages are embedded into medical images either in their spatial domain or in frequency domain. Spatial domain watermarking results in poor robustness but helps to embed high payload of watermark. Frequency domain methods embed small amount of watermark but achieves high robustness which is essential to prove the authenticity and integrity issues. Current research scenario in watermarking field embeds and extracts the watermark in frequency domain of the image. When such watermarked images are transformed into spatial domain, the real pixel values are rounded into integers and so the retrieval of embedded information is not a proper one due to rounding error problem.

The extraction process of a watermarking algorithm is very crucial to prove authentication issues. To enhance the retrieval of authenticated message, the rounding error problem is corrected in Discrete Wavelet Transform (DWT) domain by utilizing genetic algorithm. Additive approach is employed to embed the authentication message in the DWT domain of the host image. Genetic Algorithm (GA) helps to retrieve the correct watermark by minimizing the error values between the original and watermarked image utilizing Mean Square Error (MSE) measure as fitness function.

2. Related Work

Mohananthini N. et al (2016) proposed a comparison of multiple watermarking techniques based on DWT and Singular Value Decomposition (SVD) using genetic algorithm. This research elaborates three main categories of multiple watermarking techniques. In successive watermarking, the multiple watermarks are embedded one after the other to get watermarked images which is denoted as Re-watermarking technique. In composite watermarking a new SVD-DWT embedding is performed on original images. In segmented watermarking, one watermark is embedded into odd-numbered rows and columns; another watermark is embedded into even-numbered rows and columns of the original image. The experimental results show that the SVD-DWT based watermarking algorithm possesses multi-resolution description characteristics achieving imperceptibility and robustness. The optimization is performed to maximize PSNR and Normalized Correlation (NC) in multiple watermarking techniques using genetic algorithms [2].

Sridevi T et al (2013) presented a watermarking algorithm using genetic algorithm and Human Visual System (HVS). The algorithm proposed is to improve both robustness and fidelity of the watermarked image. Fuzzy Inference system is used to determine the embedding strength based on texture sensitivity property of the image. NC values achieved in the range of 0.8 -1.0 proves that system is robust to image processing attacks [3].

Seyed Sahand M. Z. et al (2013) presented the optimized image watermarking using genetic algorithm in which the security of the watermarking is improved with pre-processing operations. The

implicit errors are removed and the time complexity is decreased using genetic algorithm [4].

Rinita Roy et al (2015) proposed an optimization technique using genetic algorithm to optimize imperceptibility measure which results in high image quality watermarked image. A heuristic initialization technique to generate initial population and fitness function based on PSNR from 8-connected neighbours of each pixel is followed to optimize the quality of the stego image [5].

D. Venkatesan et al (2012) proposed optimization of fidelity in digital image watermarking using a new Genetic Algorithm based on Center of Mass Selection Operator (CMGA), to find the optimum locations for digital watermark insertion in a cover image with the focus to optimize fidelity [6].

Muhammad Jamil Anwar et al (2010) proposed block-based digital image watermarking using genetic algorithm. In the proposed method both cover and secret images are partitioned into equal size blocks. Then host pixels to embed secret image blocks using LSB embedding is intelligently selected through GA which manages the visual quality of the cover image. In the watermark extraction phase only watermarked image is required from which the secret image is reconstructed using Jigsaw Puzzle Solver (JPS) [8].

The reviewed works focus on improving the image fidelity by considering the PSNR and NC measures. When frequency domain embedding algorithm is employed the watermark extraction leads to poor correlation due to rounding error problem [9]. The watermark embedded should be extracted with high correlation to prove the copyright, authenticity and integrity issues. So the proposed research work aims to extract the watermark with high correlation measure using genetic algorithm.

3. Methodology

Watermark extraction with high correlation is main objective of developing genetic algorithm based watermarking approach. Parameters that are needed to enhance watermark retrieval by optimizing MSE measure are defined as follows:

- Chromosomes: Binary strings representing row and column size of the watermark is defined as length of each chromosome. These chromosomes act as watermarks for the input image.
- Fitness Function: Mean Square Error (MSE) measure acts as evaluation function for all the chromosomes.

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

MxN - size of the image
I – Input image
I' – Watermarked image

- Reproduction: Chromosomes which yield minimum MSE is selected.
- Crossover and Mutation: Single point crossover and mutation is applied to the chromosomes which are selected.

Parameters utilized for GA based watermark retrieval is represented in Table 1.

Table 1: Parameters used for GA based watermark retrieval

Parameters	Value
Chromosomes	Binary strings of size 128 x 128
Population	10
Crossover percentage	0.7
Mutation percentage	0.3

Iterative steps of the genetic algorithm utilize the parameters defined and generate solutions. The process is repeated until specified number of iterations. Minimum MSE value and the corresponding best chromosome are obtained. The best chromosome will be taken as watermark and embedded into the approximate DWT coefficients of the medical image. Watermarked image with minimum MSE value contains real numbers which is converted into unsigned 8-bit integers which helps to retrieve the watermark with high correlation. Instead of rounding the watermarked image, converting the image to 8-bit representation avoids rounding error problem and extracts the exact watermarks from the medical images with high correlation nearly equal to one after the application of DWT.

3.1. Watermarking Using Genetic Algorithm

The steps for optimizing MSE value that helps to retrieve the watermark are as follows:

Step 1: The fitness function, population size, crossover and mutation percentage are defined.

Step 2: The chromosomes which represent the watermark and original image are supplied as inputs for the fitness function.

Step 3: DWT is applied on the original image and generated watermark is embedded into the approximation details using additive approach to get the stego image which is described in section 3.2.

Step 4: The fitness function is evaluated for each corresponding chromosomes using original and watermarked image in which the watermark with MSE value is recorded.

Step 5: The better chromosome is obtained based on the fitness value using random selection.

Step 6: New chromosomes are recombined using crossover and mutation.

Step 7: Steps 3 to 6 are repeated until the desired number of iterations is reached.

Step 8: Watermarked image with minimum MSE value is obtained after the specified number of iterations and converted into unsigned 8-bit integers to extract highly correlated watermark using the procedure described in section 3.3.

3.2. Watermark Embedding Process

The authentication message is embedded in original image using DWT by following watermark embedding algorithm:

- Watermark image W is a pseudorandom numbers of size 128x128
- Watermark W is inserted into the frequency domain of the host image H of size 128 x 128 using additive approach.
- H is decomposed into frequency coefficients using DWT to obtain first level decomposition details cA, cH, cV and cD bands.
- The watermark is embedded into the approximation details (cA) of DWT coefficients using additive approach as follows:

$$wA(i,j) = cA(i,j) + (\alpha(i) * W(i,j))$$

wA – Watermarked approximate details.
cA – Approximate details of original image
W – Authentication message

- The image is transformed using inverse DWT with wA, cH, cV and cD bands. WIM becomes the final watermarked Image.

The watermarked image, WIM when converted into spatial domain, the real numbers are rounded into integers and hence the embedded information retrieval becomes an issue. The proposed genetic algorithm based approach converts the watermarked image into unsigned integer 8-bits and helps to retrieve embedded watermark and achieves accepted imperceptibility by optimizing watermarked image using MSE measure.

3.3. Watermark Extraction Process

Embedded message must be extracted with high correlation to prove the authentication issues. Procedure to extract the embedded message in the DWT domain is as follows:

- Final watermarked image WIM is decomposed into First level DWT coefficients as wA, wH, wV and wD bands.
- Pseudorandom numbers which acts as authentication message is extracted using the following equation

$$EW(i,j) = [wA(i,j) - cA(i,j)]/\alpha$$

EW – Extracted Watermark

wA – Approximate details of Watermarked image

cA – Approximate details of Original Image

α - Scaling factor

Extracted watermark, EW and original watermark W is used to measure the correlation using NC measure.

4. Results and Discussion

The proposed algorithm is tested with medical images by embedding 128x128 size watermark in the approximate coefficients of DWT domain. DWT based watermarked image is converted into the integer values after optimizing MSE measure to obtain GA based watermarked image. Fig. 1 to Fig. 8 depicts the results of the proposed algorithm.

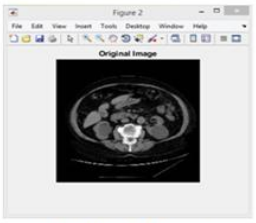

Fig. 1 Original Image

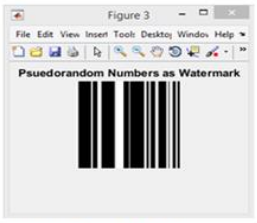

Fig. 2 Embedded Message

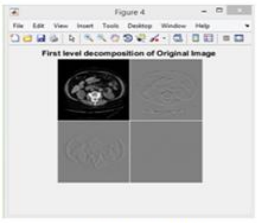

Fig.3 First Level DWT of Original Image

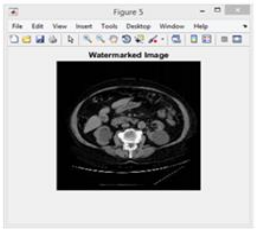

Fig. 4 Watermarked Image

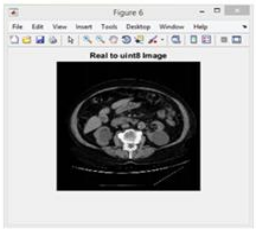

Fig. 5 Real to uint8 Image

Fig.6 Extracted Watermark

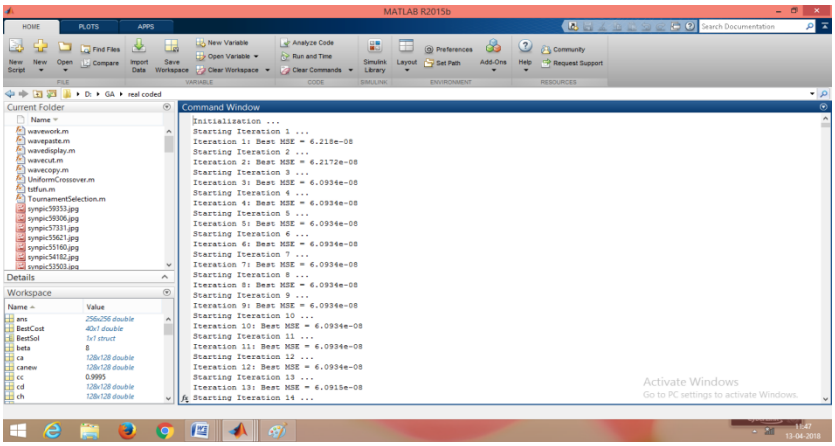

Fig. 7: Matlab window - optimized mse values

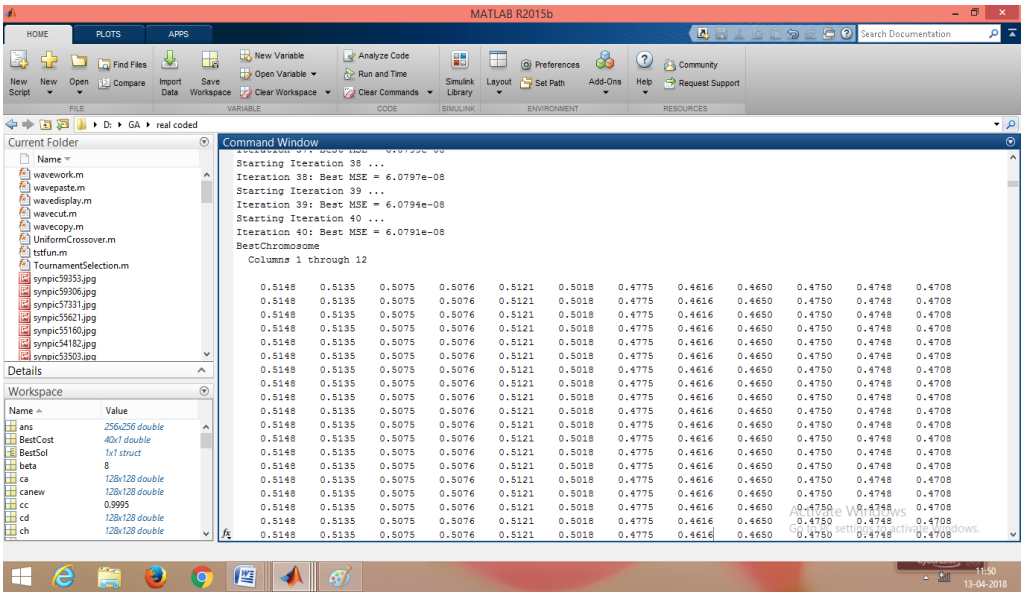

Fig. 8: Matlab window – best chromosome representing watermark

5. Performance Analysis

Error measures such as Peak Signal-to-Noise Ratio (PSNR) and Normalized Correlation (NC) are used to compute the image distortion in the watermarked images. The PSNR value is calculated as follows:

$$PSNR = 10\log_{10}\left[\frac{\sum_{i=1}^{N}\sum_{j=1}^{N}[h^*(i,j)]^2}{\sum_{i=1}^{N}\sum_{j=1}^{N}[h(i,j)-h^*(i,j)]^2}\right]$$

$h^*(i, j)$ – pixel value of watermarked image
$h(i, j)$ - pixel value of original image[10]
N x N – size of the image
Recommended PSNR values must be > 35 decibels for medical images
Normalized Correlation (NC) between the extracted and original watermark is calculated by the following equation

$$NC = \frac{\sum_i\sum_j W(i,j) * EW(i,j)}{\sqrt{\sum_i\sum_j W(i,j)^2 * \sum_i\sum_j EW(i,j)^2}}$$

W – Original watermark
EW– Extracted watermark
PSNR and NC values are tabulated in Table 2 for genetic algorithm based watermarked images. The alpha (α) value of 0.001 is used for embedding watermark in frequency domain using additive approach. Watermark of size 128x128 is used in DWT and GA based embedding and tested with multi-modality medical images.[11]

Table 2: PSNR and NC values of GA based Watermark Embedding

S.No.	Test Images	Number of Iterations	PSNR	NC
1	Synpic4349.jpg	10	43.3971	0.9950
		20	42.4491	0.9931
		30	44.7166	0.9958
		40	**44.8194**	**0.9945**
2	Synpic8322.jpg	10	41.9383	0.9975
		20	42.3490	0.9976
		30	**43.6715**	**0.9985**
		40	42.5979	0.9985
3	MR-knee.jpg	10	39.5032	1
		20	40.0885	1
		30	39.584	1
		40	**41.0878**	**1**
4	MR-head.jpg	10	34.3854	1
		20	35.3878	1
		30	**36.5977**	**1**
		40	35.0368	1
5	Synpic28330	10	36.8847	0.9998
		20	36.0463	1
		30	**37.5769**	**0.9998**
		40	37.3779	0.9998
6	Synpic33414	10	34.5631	0.9998
		20	**37.2750**	**0.9998**
		30	34.5086	0.9998
		40	35.7459	1

Proposed algorithm embeds the watermark with less image degradation by achieving PSNR values above 35 decibels and extracts the watermark by rounding the real to integer numbers with NC values nearly equal to one. Genetic based watermarking and retrieval produces high PSNR values when compared to the existing watermarking systems which are depicted in Table 3.

Table 3: Comparison of Proposed and Existing Methods

Comparison Factors	Proposed-MSE based Authentication	N.Mohananthini et al (2016)	Rinitha Roy et al (2015)
Imperceptibility	35-45dbs	35-50dbs	30-40dbs
Watermark Size	128 x 128 (1,31,072 bits)	48 x 48 (18,432 bits)	256 bits
NC values	0.9931 to 1.000	0.8081 to 0.9989	--

6. Conclusion

Proposed genetic algorithm based medical image watermarking approach embeds an authentication message with 128x128 size with less image distortion by achieving acceptable PSNR values. The approach extracts watermark from the watermarked image after converting the real values to unsigned 8-bit integer and achieves NC value nearly equal to one. Watermarked image is obtained optimizing MSE measure using genetic algorithm. Hence the proposed genetic algorithm based multi-modality medical image authentication system helps to achieve less distorted watermarked image and highly correlated watermark.

References

[1] Mousavi SM, Naghsh A & Abu-Bakar SAR, "Watermarking techniques used in medical images: a survey", *Journal of digital imaging*, Vol.27, No.6, (2014), pp.714-729.

[2] Mohananthini N & Yamuna G, "Comparison of multiple watermarking techniques using genetic algorithms", *Journal of Electrical Systems and Information Technology*, Vol.3, No.1, (2016), pp.68-80.

[3] Sridevi T & Fathima SS, "Watermarking algorithm based using genetic algorithm and HVS", *International Journal of Computer Applications*, Vol.74, No.13, (2013), pp.26-30.

[4] Ziabari SSM, Atani RE, Keyghobad K & Riazi A, "The optimized image watermarking using genetic algorithm", *Current trends in technology and science*, Vol.2, No.6, (2013), pp.359-363.

[5] Roy R & Laha S, "Optimization of Stego Image retaining secret information using Genetic Algorithm with 8-connected PSNR", *Procedia Computer Science*, Vol.60, (2015), pp. 468-477.

[6] Venkatesan D, Kannan K & Balachandar SR, "Optimization of Fidelity in Digital Image Watermarking Using a New Genetic Algorithm", *Applied Mathematical Sciences*, Vol.6, No.73, (2012), pp.3607-3614.

[7] Abdullatif M, Zeki AM & Chebil J, "Wavelet Watermarking on Medical Images", *Proc of the International Conference on Artificial Intelligence in Computer Science, Malaysia*, (2013), pp.147-156.

[8] Anwar MJ, Ishtiaq M, Iqbal MA & Jaffar MA, "Block-based digital image watermarking using Genetic Algorithm", *IEEE 6th International Conference on Emerging Technologies (ICET)*, (2010), pp.204-209.

[9] Shih FY, *Digital watermarking and steganography: fundamentals and techniques*, CRC press, (2017).

[10] G, Abikhanova, A Ahmetbekova, E Bayat, A Donbaeva, G Burkitbay (2018). International motifs and plots in the Kazakh epics in China (on the materials of the Kazakh epics in China), Opción, Año 33, No. 85. 20-43.

[11] A Mukanbetkaliyev, S Amandykova, Y Zhambayev, Z Duskaziyeva, A Alimbetova (2018). The aspects of legal regulation on staffing of procuratorial authorities of the Russian Federation and the Republic of Kazakhstan Opción, Año 33. 187-216.