REVERSIBLE WITH ROBUST WATERMARKING TECHNIQUE FOR MEDIAL IMAGE PROESSING APPLICATION

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Abstract*- Digital watermarking has an essential application to safeguard and authenticate the medical images. The reversible method is a best suitable method for watermarking with security of medical image as compared with other watermarking method. Conceal image dependent embedding capability and lacks of robustness are the most essential concerns of the reversible watermarking methods. To overcome these issues, a reversible technique with a robust watermarking method is proposed. A reversible technique is basically dedicated to deal with medical images in which is pretty easy to partition the complete medical image into two regions like an anatomical object (Region of Interest) and the black surroundings area behind the object (Non Region of Interest). The proposed reversible watermarking scheme has also been simulated and experimented to validate the robustness property against numerous image processing attacks and acceptable outcomes are achieved. The MATLAB simulation results show that the proposed algorithm generates excellent performances in the embedding capability and the PSNR values. The performance of proposed reversible technique with robust watermarking algorithm has been compared to those presented by the conventional algorithm in terms of the embedding part against the PSNR, MSE and SSM values of the watermarked image.

Keyword- Arnold Transform, Digital watermarking, Discrete Wavelet, Medical image, Reversible watermarking, Robustness against image attack, Singular value decomposition,

I. INTRODUCTION

Watermarking in medical area has a lot of helpful applications like analysis, consultation between clinicians, and remote education of medical people. Sharing medical images among clinicians, radiologists, and offers a platform for arguing and consulting analytic and curative procedures. In this situation, the electronic patient description and medical images are sent independently to the target. By means of watermarking methods and combining the patient description into the medical images will not only assure the privacy and safety of the sent information but also the reliability of the medical images. Moreover, verification of watermarks and corrupting recognition techniques can be used to recognize the basis of medical images and establishing the tampered region, respectively.

The aims of medical image watermarking can be separated into two divisions such as to verification and to conceal the patient information. In [1], separated medical image watermarking schemes into two distinct categories according to their use: verification, information hiding. The only reason of this work is content verification of processed tomography images. The most essential spotlight is on a blind, weak watermarking technique, which is surrounded on the region of noninterest of medical images consequently that the image superiority of the region of interest is conserved. The segmentation process has been used instead of representing an ellipse/square for sorting out the region of non interest (RONI) and region of interest (ROI). The algorithm is declared to carry out segmentation resourcefully by exact region of interest recognition while raising the embedding ability. The problem of this method is that the inserting of the watermark was finished in region of non interest only. As an invader can divide the region of interest and set his own region of non interest and inserts his watermark on it, region of interest may not be protected against cruel attacks. The additional limitation is that this technique cannot distinguish between calculated and unplanned damage, as any operation on the image indicates that the image is not realistic.

The other watermarking technique was an accomplished in [2], whose function was reliability authentication and validation of ultrasound images. In the first step, the region of interest was divided by a rectangular form from the region of non interest. The next step was to determine the hash value of an entire image by measures of a hash utility. To improve security, a private key was used to generate a hash value as well as a confidential key for the implanted watermark. The final phase was to insert the hash value into the least significant bits of region of non interest. These schemes are irreversible [3].

In [4], the idea was verification and official document fortification. The watermark was an arrangement of the patient information and the region of interest feature. Earlier to watermark implanting, the ratio of region of interest and region of non interest was described to maintain the regularity of region of interest explanation by different doctors. The Peak Signal to Noise Ratio (PSNR) of the watermarked representation is not revealed in this work.

The other scheme was based on difference expansion method is an efficient, simple and reversible system with a high implanting facility [5]. In this difference expansion technique, the watermark was an implanted into the region close to the region of interest, but not inside the area. This technique can save the superiority of the image in the area of interest, but would not safeguard the region against attack. In fusion method to attain region of interest validation, tamper localization, hiding patient records, and improving the tampered area [6]. In this fusion method, the input image was separated into region of interest and region of non interest. Then, by measures of difference expansion, patient records and region of interest hash implication were implanted into the region of interest. Secondly, by means of a robust method, retrieval information, which built-in the region of interest embedding plan, the normal value of blocks inside region of interest, and a compacted shape of region of interest were added into the region of non interest. Lastly, by means of Discrete Wavelet Transform (DWT), a second watermark was implanted into the boundary of region of non interest.

This technique shows tolerable strength against both salt and pepper noise and cropping attack this process is the manual choice of region of interest in the implanting part. In addition, this breakable watermark may not be a suitable technique for implanting the patient information. This is for the reason that the patient information is essential information and breakable methods cannot safeguard it against attacks.

Watermarking in a particular structure in an approach [7], the degraded details of the medical image after watermarking were improved by means of reversible assets. Rewards of this technique are simplicity, high security, high capacity, and reversible superiority of the patient information. Conversely, this system is incompetent of managing overflow/under flow. The other drawback of this technique is the use of a symmetric input for cryptography, which has lower safety than an asymmetric input.

In [8], a blind hybrid watermarking method was used. In this method, instead of using histogram modification for preventing the underflow or overflow, a location map was generated and the suspect block was left without watermarking.

Reversible watermarking is based on the process of watermark insertion into a medical image, transmission of the watermarked image, and the complete removal of the watermark from the image on the recipient's side [9]. After watermark removal, the original image is completely restored and unchanged. Once the watermark is removed from the image, the image is no longer protected. Evidently, there is a requirement to transmit those differential values in a secure way. These differences are used at the recipient's side to remove the watermark and reconstruct the original image. As an advantage of this method the possibility of securing the whole image by robust watermarking methods and higher capacity than region of non interest watermarking. The major disadvantage is the need to create another channel for secure transport of differential information [11-13].

In zero watermarking, a watermark is not added completely into the watermarked information. As a consequence, it can be measured as a lossless as no information is modeled. The most important advantages are high strength and zero misrepresentation of the watermarked image. The enormous drawback is the need to develop an absolutely complex structure for watermark comparison and storage. This technique is unacceptable for images projected for the analysis of metastasis for which precise bit pixel value as fine as its settings is important. A successful method intended for enhancing the feature of image using a 2-D lift DWT based method for the analysis of the effect of PSNR for images. The watermark is created as a random sequence [14, 15]. A complete sensing situation was unspecified which involves the strength of the watermark.

The robust watermark is made up of patient information, doctor identification code, and LSBs of the region of interest, which after encryption were embedded into the region of non interest of the medical image [16-19]. The fragile watermark was a binary pattern and was embedded on region of interest for integrity control. In [20], robustness is realized by using two methods such as a reversible method and a robust watermarking technique. It provides robustness to the watermark elimination for occurrence against JPEG compression. This method is not robust against attacks and the given example does not show acceptable results.

In this paper, a blind image watermarking method has established because only a secret key is necessary in the extraction process. This method is appropriate for web applications where the original conceal are not offered for the receivers. This method makes utilize of a binary image as watermark information for shielding the copyrights of images. The necessities were met by the proposed method exploiting the desirable properties of the Discrete Wavelet Transform (DWT). The high frequency subband was preferred to embed the image. In this paper, we propose a blind, reversible and robust watermarking method based on Single Value Decomposition (SVD)- Discrete Wavelet Transform (DWT).

The paper is structured in different sections; section II presents the watermarking using DWT. In section III, we propose a DWT and SVD based watermarking method. Section IV presents the particulars of experiments completed with their results using MATLAB; lastly conclusions are drawn in section V.

II. WATERMARKING USING DWT

The decomposition of image signal using DWT is given by

$$\mathbf{y_{low}(n) = \sum_{k=-\infty}^{\infty} x(k)l(2n-k)} \qquad (1)$$

$$\mathbf{y_{high}(n) = \sum_{k=-\infty}^{\infty} x(k)h(2n-k)} \qquad (2)$$

Where x(k) is the input image signal, l(k) and h(k) are low pass and high pass filter. $y_{low}(n)$ and $y_{high}(n)$ are the outputs of low and high pass filter after sampling by the value 2. Then the reconstructed output becomes in equation

$$\mathbf{x(k) = \sum_{n=-\infty}^{\infty} y_{low}(n)l(2n-k) + \sum_{n-\infty}^{\infty} y_{high}(n)h(2n-k)} \qquad (3)$$

Image has a two dimensional signal. In DWT, the mother wavelet is given by

$$\mathbf{\Psi_{i,j}(t) = \alpha_0^{-\frac{i}{2}}\Psi(\alpha_0^{-i} t - j\beta_0)} \qquad (4)$$

Where T is the mother wavelet, α_0 and β_0 is the scale and translational parameter. If $\alpha_0 = 2$ and $\beta_0 = 1$ for dyadic wavelet then the equation () becomes

$$\mathbf{\Psi_{i,j}(t) = 2^{-\frac{i}{2}}\Psi(2^{-i}t - j) \ldots \ldots i,\ j \in Z} \qquad (5)$$

DWT decomposes the image into four frequency bands such as LL, HL, LH, and HH band. LL band is for low frequency, LH and HL band is for middle frequency and HH band is for high frequency band. LL band represents quite accurate particulars, HL band provides horizontal particulars, LH gives vertical particulars and HH band highlights transverse particulars of the image [7]. In this, HH band to implant the watermark as it includes the better details and gives irrelevantly to the image energy. Consequently watermark embedding will not change the perceptual faithfulness of conceal image. In addition, extreme energy LL band coefficient cannot be squeezed ahead of some position as it will strictly influence perceptual property. It is experimental that watermark added in HH band survives guaranteed image processing functions like intensity manipulation, noise addition and restriction of the human visual structure can be exploited by adding watermark into HH band. Human visual system fails to distinguish changes complete to HH band. The method is established on the proposal of substituting particular values of the HH range with the particular values of the watermark. It is experimental that singular values of several test images lie among 77 to 182. But a watermark is preferred such that its particular values lies contained by the specified range, subsequently the energy of the particular values of watermark will be roughly equal to the energy of the particular values of the HH band. Thus the substitution of the singular values will not influence perceptual characteristic of image and the energy content of HH band.

III. PROPOSED ALGORITHM

The proposed method embeds watermark through decomposing the mask image using discrete wavelet transform. A visual cover based on person visual system characteristics is used for calculating the load issue for each wavelet coefficient of the host image. Discrete wavelet transform based techniques can model the person visual coordination more precisely than Discrete Fourier Transform (DFT) and Discrete Cosine Transform (DCT). Consequently, by finding less receptive areas for the individual visual system, the structure can embed additional watermarks in that area without corrupting the feature of the watermarked image. Moreover, these techniques are the most strong against noise. Furthermore, in association to discrete cosine transform based transform, wavelet based techniques create less image artifacts since the methods do not involve the image to be decayed into blocks.

In watermarking uses, lower breakdown levels are more susceptible to image modification as they exhibit a lower quantity of energy as compared to higher breakdown levels. The energy equation is in (1).

$$\mathbf{E_d} = \frac{\sum_i \sum_j |\mathbf{I_d(i,j)}|}{\mathbf{X_d Y_d}} \qquad (1)$$

Where d is the breakdown level, I_d denotes the sub band coefficients, and X_d and Y_d are the dimensions of sub band.

The idea of proposed singular value decomposition illustrates that a rectangular matrix can be decomposed into three matrices of X, conjugate transpose Y, and D. X and Y are orthogonal square matrices and D is a rectangular diagonal matrix with its patterns organized in descending order. The representation of a square matrix W of order of N after singular value decomposition transform is shown in equation (2).

$$\mathbf{W} = \mathbf{XDY^T} = [\mathbf{x_1}, \mathbf{x_2}, \dots\dots \mathbf{x_N}] \begin{bmatrix} \Delta_1 & \cdots & \\ \vdots & \ddots & \vdots \\ & \cdots & \Delta_N \end{bmatrix} \begin{bmatrix} \mathbf{y_1} \\ \cdot \\ \cdot \\ \cdot \\ \mathbf{y_N} \end{bmatrix} \qquad (6)$$

Where $X \in R^{N \times N}$ and $Y \in R^{N \times N}$ are unitary matrices, i.e., $XX^T = I_n$ and $YY^T = I_n$. The columns of matrices X and Y are called the left and right vectors of singular matrix W respectively. As stated before, $D \in R^{N \times N}$ is a diagonal matrix (D =diagonal ($\Delta_1, \Delta_2 \dots \Delta_N$)) with singular values Δ_i (i =1, 2…N). The operator T is used for the conjugate transpose function. For matrix W of order M (M≤N), if diagonal entries of matrix D preserve their descending order as $\Delta_1 \geq \Delta_2 \geq \dots \geq \Delta_M \geq \Delta_{M+1} \geq \Delta_{M+2} \dots = \Delta_N = 0$, then the matrix W can be described as in equation (3).

$$\mathbf{W} = \sum_{\mathbf{i=1}}^{\mathbf{M}} \Delta_{\mathbf{i}} \mathbf{x_i} \mathbf{y_i} \qquad (7)$$

Where x_i and y_i are the i^{th} eigenvector of X and Y and Δ_i is i^{th} singular value.

The Arnold transform is a common and simple algorithm for image security. The Arnold transform equation can be described as

$$\begin{bmatrix} \mathbf{x_{i+1}} \\ \mathbf{y_{i+1}} \end{bmatrix} = \begin{pmatrix} \mathbf{x_i} \\ \mathbf{y_i} \end{pmatrix} \begin{bmatrix} \mathbf{1} & \mathbf{1} \\ \mathbf{1} & \mathbf{2} \end{bmatrix} (\mathbf{mod\ W}) \qquad (\mathbf{8})$$

Where $[x_{i+1}, y_{i+1}]$ is a scrambled image coordinate, (x_i, y_i) is the original image coordinate and W is the image width. This transform has good periodicity property. This transform is applied in the proposed watermark method to obtain guarantee security.

A. Embedding Process

The cover image is a size of m*n bit image and the watermark image is a size of k*l image having either white color (1) or black color (0) pixels. To provide its embedment, with performing four pace wavelet decomposition ahead the cover image, it chooses coefficients of the high frequency subband to insert the watermark, and to calculate the weight factors for wavelet. Both the watermark image and the high frequency subband are changed from 2-D to 1-D, later than changing the high frequency subband to a vector, the high frequency subband vector is separated into little blocks each containing a volume of eight pixels. Simply one pixel from each block is used to insert individual pixel of the watermark image, the selecting process of these blocks is arbitrary by simulated random key; this simulated random key is produced by random variation function in MATLAB. The range of key is equal to the number of blocks. Fig.1. gives the b l o c k d i a g r a m f o r embedding process. The embedding technique is achieved after selecting a few pixels from each block, the mean value for each block is calculated, and this mean value is useful for the embedding and extracting process. Owing to this average of block is merging of watermark intensity, and it raises the watermark strength against threats. Watermark intensity factor modulation is skilled through a cover giving pixels by pixel evaluate of the susceptibility of the person eye to restricted image perturbations.

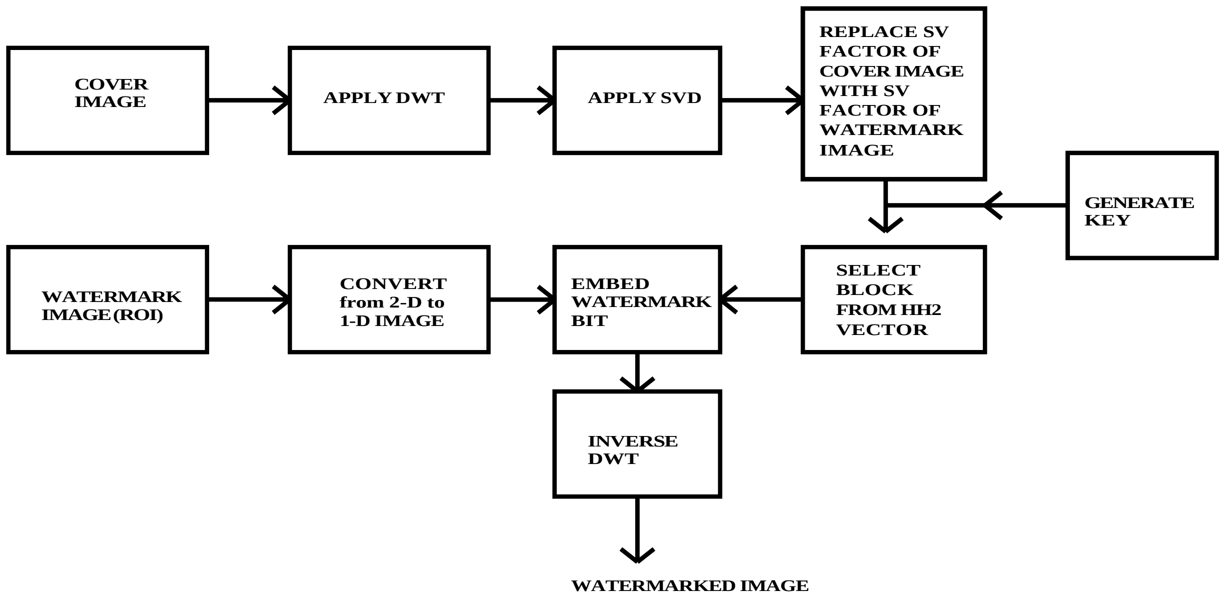


Fig.1. Block Diagram for Embedding Process

B. Procedure for Proposed Watermark Embedding Algorithm

Input: Cover Image, Watermark Image (ROI)
Output: Watermarked Image

Step 1: Read Gray Scale Cover Image size of m*n.
Step 2: Decompose Cover Image using Haar Transform.
Step 3: Apply SVD to HH sub band of Cover Image found in step 2.
Step 4: Read Gray Scale Watermark Image size of k*l.
Step 5: calculate mean value of pseudo random sequence with key K.
Step 6: Set a predefined threshold and counter value.
Step 7: If mean value is greater than threshold then generate new scrambled key K1 with the help of Arnold transform.
Step 8: embedding of scrambled watermark with cover image then apply SVD to generate new singular value.
Step 9: Apply Inverse SVD to get new sub band components.
Step 10: Apply Inverse DWT to produce watermarked image.

C. Extraction Process

The proposed DWT method is blind in the logic that watermark removal is proficient exclusive of referring to the cover image. The block diagram for extracting process is as shown in Fig.2. In the watermark removal method, the user can remove the watermark image without re calculating the weighting factor S and subsequently utilize it to remove the image. After choosing high frequency subband for removing the watermark, change high frequency subband from 2-D to 1-D, then separate the high frequency vector into non intersecting blocks with dimension equal to different size pixels. The similar key that was used for implanting method is created to choose the similar nonintersecting blocks. Afterwards calculate the mean value of each building block, then determines the modulus for this mean as divided by t w o . This modulus is used for image (ROI) bits extraction. In order to remove the watermark image (ROI) from watermarked image, the user have to recognize the subsequent necessities such as dimension of watermark image (ROI), nature of filter to decompose the watermarked(cover image with ROI image) into four levels DWT, the sites of the nonintersecting blocks to remove from high frequency where the watermark image (ROI) was implanted.

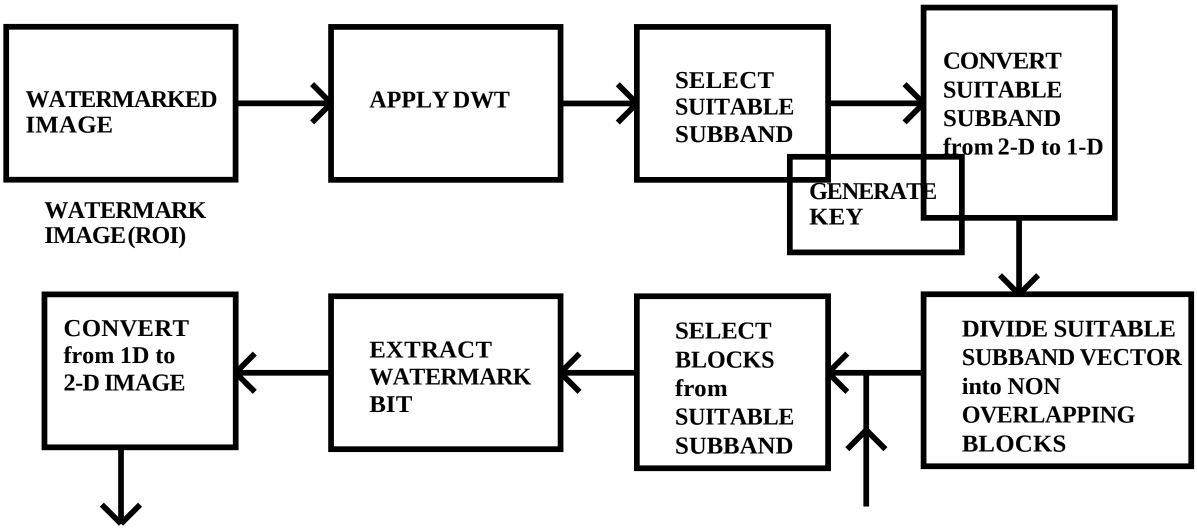


Fig.2. Block Diagram for Extracting Process

D. Procedure for Proposed Watermark Extraction Algorithm

Input: Watermarked Image, Cover Image
Output: Extracted Watermark Image

Step 1: Read Watermarked Image.
Step 2: Apply DWT to Watermarked Image to recovered sub band components.
Step 3: Apply SVD to recovered sub band components.
Step 4: Read Gray Scale cover Image size of m*n.
Step 5: Find scrambled watermark with key K1 using Singular Value component.
Step 6: Apply transform to scrambled watermark to produce Extracted Watermark Image with key K.

E. Key Process for Embedding & Extraction

The key must be random, as a result that an attacker cannot guess them. Threshold limit plays a significant part as mapping and it is utilized to randomize the mapping and improving the protection level. The key should stay strong against signal processing operation. Change in key spots at decoder produces verification to be unsuccessful. Hence, key bits ought to be implanted into high level energy state for enhanced robustness. The part of the key is reserved trivial to reduce alters in the high level energy coefficients. It should keep on robust against broad range of attacks consequently one group of key bits are fixed into fourth level lower subband and one more set is fixed into fourth level higher subband with scrambled key to guarantee retrieval from at least one of the subband. The encoder will insert the watermark (ROI) and keys according to the proposed method. Decoder removes the keys and fits it with the restored key for verification matrices. If corresponding condition is fulfilled, after that decoder will remain estimating watermark (ROI).

IV. EXPERIMENTAL RESULTS

Several attacks are used to analysis the strength of the watermark. All the attacks were experienced with MATLAB. The superiority of the watermarked representation is superior in terms of PSNR and perceptibility. It can be observed that all PSNR standards are greater than 40 dB which is absolutely good enough for the person eye, with just about no notice of watermark survival.

The proposed method can be remove the image without need to the initial image which is implanted in the cover image and this method can be utilized any grayscale image as cover image. All attacks that can modify or influence the high-level frequency components of the watermarked representation cause corrosion for the recovered image. This achieve from the reality that embedding has been skilled by changing the values of certain coefficients in the high frequency subband in DWT. The following attacks such as image tampering, Gaussian noise, cropping attacks and resizing etc as shown in Fig.3.

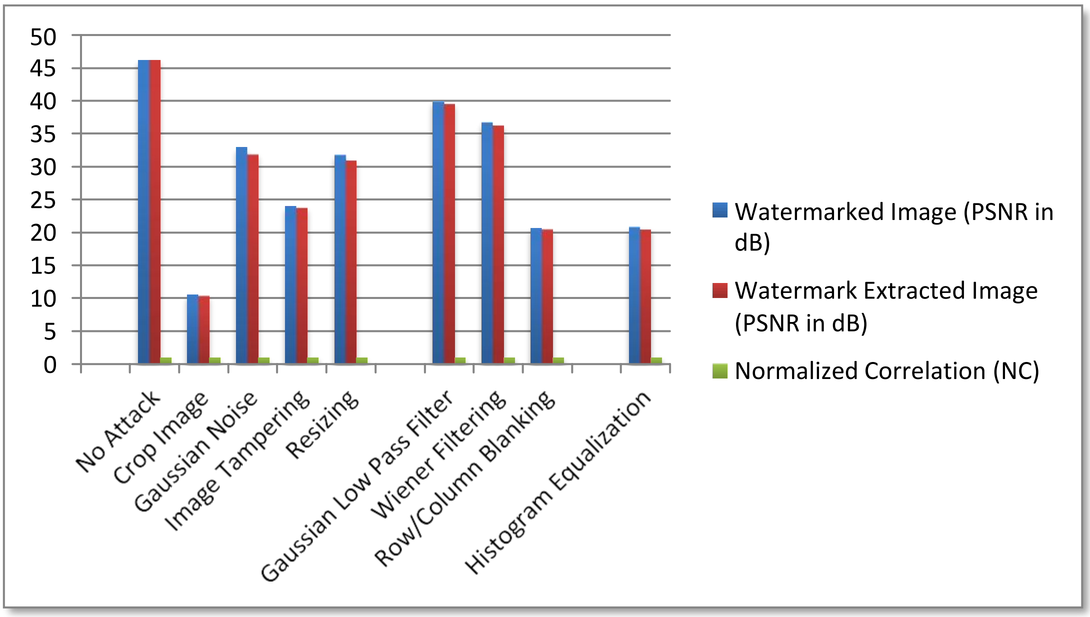
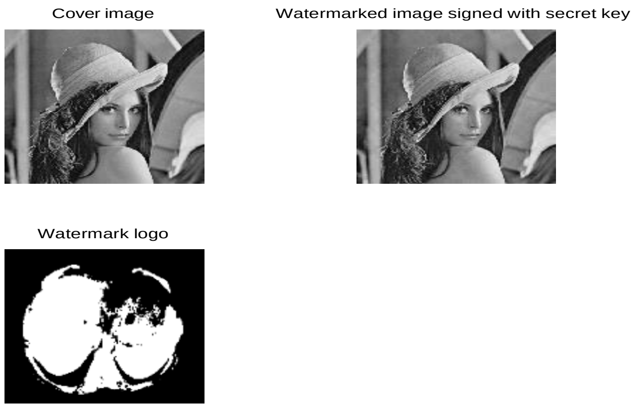


Fig.3. Comparison between Different Attacks in Watermarked Image

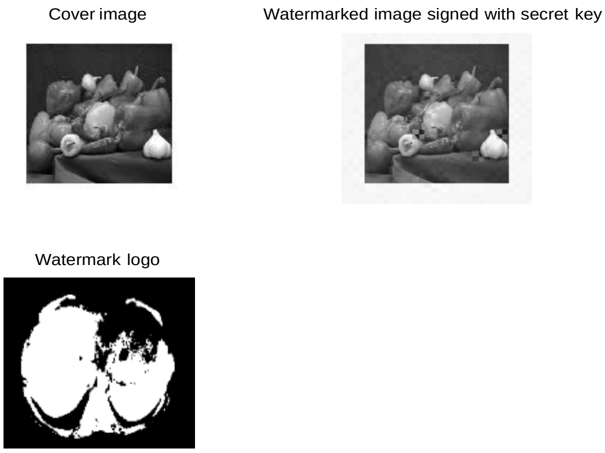
Fig.4. shows watermarking image (ROI) extracted from lena watermarked (512×512), pepper (512*512) and mandril (512*512) images, after revealing the watermarked image to several attacks. The Normalized Correlation (NC) is used to express feature of the restructured image

for each one of the attacks.



Cover image(lena), Watermark Image (PMC4573419_gr1) ,Watermarked Image

Reversible Extracted watermark image

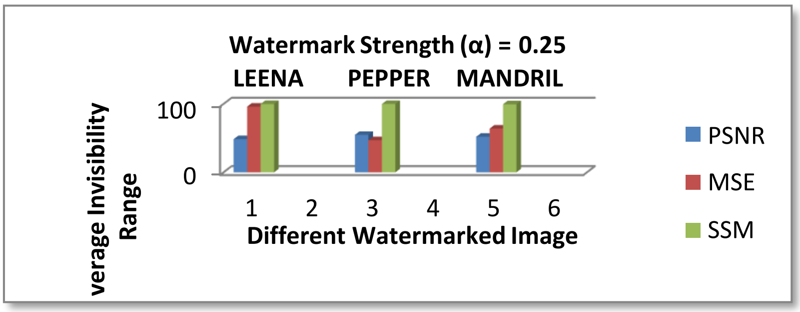


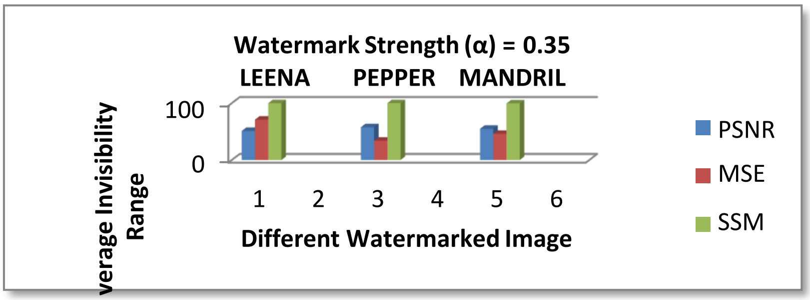
Cover image(peppers),Watermark Image (PMC4573419_gr1) ,Watermarked Image

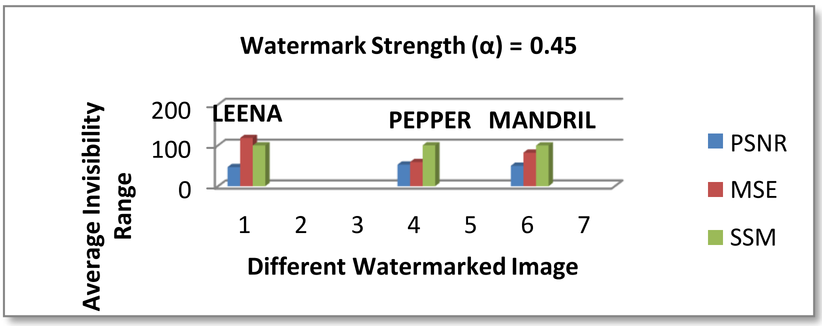
Reversible Extracted watermark image

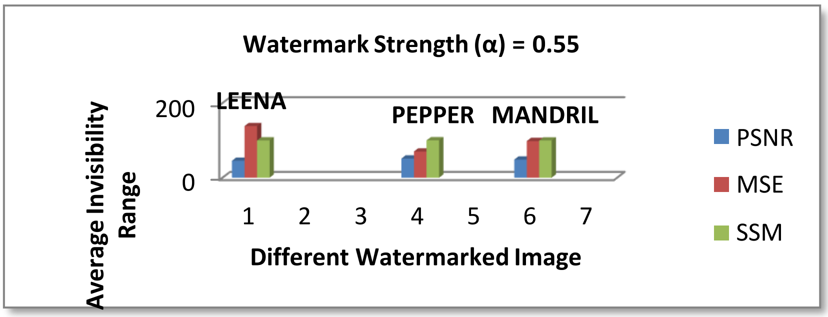
Cover image (mandril), Watermark Image (PMC4573419_gr1) ,Watermarked Image

Fig.4. Extracted Reversible Watermark Image with NC=1









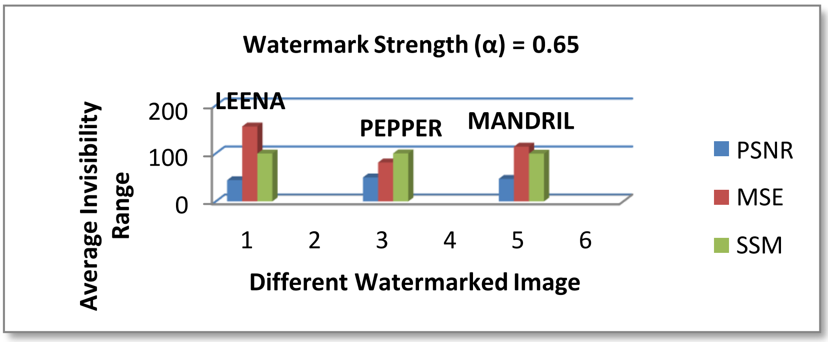


Fig.5. Comparison between Three Performance Measures of PSNR, MSE and SSM with Different Watermark Strength for Three Different Images

The primary characteristic for watermarking of medical image information is invisibility. It is calculated by constraints like Peak Signal to Noise Ratio (PSNR), Mean Square Error (MSE) and the Structural Similarity Metric (SSM). Thus, to determine the strength and invisibility of the watermark, there are three routine procedures are measured such as Peak Signal-to-Noise ratio (PSNR), Mean Square Error (MSE), and the Structural Similarity Metric (SSM).

Fig.5. shows that the PSNR, MSE, and SSM values attained from MATLAB tool for various values of Watermark Strength (α). The PSNR and SSM values are calculated by the following equation (9) and (10)

$$\mathrm{PSNR} = 10 \log \frac{P^2}{\frac{1}{D1D2}\sum_{m=1}^{D1}\sum_{n=1}^{D2}\{Io(m,n)-Iw(m,n)\}} \qquad (9)$$

In equation (1), where P is the maximum pixel value, m and n is the original image watermarked image and D1, D2 are horizontal and vertical dimensions of the image.

$$\mathrm{SSM}(m,n) = \frac{(2\mu_m\mu_n + c_1)(2\sigma_{mn} + c_2)}{(\mu_m^2 + \mu_n^2 + c_1)(\sigma_m^2 + \sigma_n^2 + c_2)} \qquad (10)$$

In equation (10), where m and n is the original and watermarked image, μ is the average value, σ is the MSE of variance, σ_{mn} is the covariance and c1, c2 are constant for avoiding instability.

Table.1. Comparison between Different Watermarking Algorithms with Three Different Parameters for Lena Image

Watermarking Algorithm	MSE	PSNR (dB)	SSM
Adaptive Watermarking Technique	11.5	36.17	0.9
DCT based Watermarking Technique	14.5	41.78	0.92
Robust Watermarking Technique	13	39.01	0.95
Proposed Watermarking Technique	**15**	**45**	**0.99**

From the results specified in Fig.5 and Table.1, it can be observed that the value for PSNR is preserved above 41.81 dB for all values of Watermark Strength cases. As the image feature of the watermarked images expands with better values of PSNR, this result illustrates that the proposed method keeps the feature of the watermarked images as a result that it is not possible for the person eye to visually notice the existence of any watermark in it. For instance the average PSNR value for the pepper image is 54 dB, which is the highest value among all. The average value of SSM for the pepper image is moreover the maximum value among all other images. This means that the pepper image is stronger with respect to noise. The cover image with same sizes were selected and their corresponding watermarked images with value of α = 0.65 were utilized to approximate the embedding facility. Since the proposed method deliberates the midpoint of the cover image, which is preferred based on the perceptually essential region, the focal point is in the midpoint of the image to approximate the embedding capacity. The proposed method considers the midpoint sector of a cover image, which offers numerous advantages in term of high performance and robustness.

V. CONCLUSION

Using the combination of the image SVD process and the robustness of the DWT domain, we have developed a robust encoded watermarking method for copyright protection applied to images. The watermark imperceptibility of the proposed method was estimated in terms of three image quality metrics of PSNR, MSE and SSM, Watermark strength of the proposed method is calculated using an extensive range of attacks and an absolutely excellent implementation is attained. Since the estimation outcomes, the proposed method outperforms the methods proposed in other methods newly proposed for image watermarking, in terms of accuracy and imperceptibility. Experimental outcomes explain that the proposed method is strong against destructive attacks. Acquired strength against geometric, manipulation of signal processing and collective attacks, compact design and the high imperceptibility of the proposed method prepare it to be applied in different range of application. In future work, the proposed technique will be extended to the verification of digital audio and video.

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