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Medical Image Watermarking using Multi Ridgelet and Fast ICA

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***Abstract*— The medical field along with computer field grows in a rapid manner. In telemedicine and tele-diagnosis authentication of medical images are very important to the patient ,doctor and Insurance company. The youngsters are also keen in knowing about the treatment methods and procedures. But no one likes to tell about the disease in open hall. So there is always an urge for watermarking of medical images. So in this work we use the concept of multi ridge let and fast independent component analysis. Since multi ridge let is a good way to enhance edges and reduce the noise. In this method we have calculated the structural similarity index measure (SSIM), mean square error(MSE) and peak signal to noise ratio(PSNR) .The experimental results are compared with the existing methods and found to be very effective.**

***Keywords*— fast ICA, mean square error(MSE) , multi ridgelet , peak signal to noise ratio(PSNR) structural similarity index measure (SSIM),telemedicine , tele diagnosis**

I. Introduction

Multimedia and communication technology provided new ways to store, access and distribute medical data in a digital format. Watermarking usually consists of the use of perceptually invisible authentication techniques. That is a predefined "controlled" distortion is introduced in the multimedia data. The goals are i) verification of the owner and ii) the detection of forgeries of an original image. Medical

Imagery is a field where the protection of the integrity and confidentiality of content is a critical issue due to the special characteristics derived from strict ethics, legislative and diagnostic implications [1]. Medical images should be kept intact in any circumstance and before any operation they must be checked for [2].

Many classifications are available for digital image watermarking. The common taxonomy is embedding in spatial and frequency domain. Spatial domain methods are not robust against various attacks and are less complex [3,4].In spatial domain the intensities of pixel are modified and embedded. In transform domain when image is inverse transformed watermark is distributed irregularly and this makes the attacker confused. Generally transform domain methods are superior to spatial domain methods. Some of the transform domain methods are Fourier transform [5], Discrete cosine transform, fast Fourier transform, wavelet transform[6]. The transform domain coefficients are altered to embed the watermark and finally inverse transform is applied to obtain the watermarked digital data.

Schyndel et al. [3] have proposed two methods using bit plane manipulation of the LSB and the other method based on the linear addition of the watermark to the image data, which is more difficult to decode, offering inherent security. The watermarking scheme employed in spatial domain using hash functions and in some works are presented in the most popular watermarking schemes based on the Spread Spectrum. The first k highest magnitude DFT/DCT coefficients of the image is used for watermarking and extraction is done by comparing the DFT/DCT coefficients of the watermarked and the original image. Shinfeng et al.[6] proposed a robust DCT technique watermark is embedded in low frequency. Barni et al. [7] have proposed a watermarking algorithm, which operates in the frequency domain, embeds a pseudo-random sequence of real numbers in a selected set of DCT coefficients**.** The fractional Fourier transform based watermarking scheme for the multimedia copyright protection is also done .After decomposing the image via FRFT, transformation coefficients are reordering in non increasing sequence and the watermark is embedded in the middle coefficients. Feng et al. [8] have proposed a blind watermarking algorithm in which multiple chirps are used as watermark and embedded in the spatial domain directly but detected in the FRFT domain. Yu et al. [9] have used the same logic proposed by Feng et al. [8], the only difference is that the embedding is done in FRFT domain where watermark

Position and the transform order are used as the encryption keys. Xia et al. [10] have added a pseudorandom sequence to the largest coefficients of the detail bands where perceptual considerations are taken into account by setting the amount of modification proportional to the strength of the coefficient itself. Watermark detection is achieved through comparison with the original un-watermarked image. Barni et al. [11] proposed a method based on the characteristics of the human visual system operating in wavelet domain. Based on the texture and the luminance content of all image sub-bands, a mask is accomplished pixel by pixel. Kundur et al. [12] proposed the use of gray scale logo as watermark. They addressed a multi resolution fusion based watermarking method for embedding gray scale logos into wavelet transformed images via salience factor. Wang et al. [13] and Zhang et al. [14] proposed a new watermarking algorithm based on wavelet tree quantization. The detailed survey on wavelet based watermarking techniques can be found in [15].

A multi ridge let transform along with fast ICA is proposed in this paper. The experimental results of the proposed method are compared with the already available watermarking paper.

In the organization of the paper the history of watermarking methods is given in section I , a brief note on ridge lets is given in section II, a brief overview of fast independent component analysis is given in section III, Watermark embedding and extraction is given in section IV. Results and conclusion are given in section V.

II. RIDGELET TRANSFORM

Ridgelet transform deals with line or super-plane singularities. The general overview is given below.

Let Ψ be in L2(R) with sufficient decay and satisfies the admissibility condition,

KΨ := $\int |\hat{\Psi}(\xi)|^2/|(\xi)^2 d\xi \subset \infty$ ……………..………..(1)

That KΨ = 1.

For a> 0,b ∈ R and Θ ∈[0,2π].

In 2-D, points and lines are related via the Radon transform, thus the wavelet and ridgelet transforms are linked via the Radon transform. More precisely, denote the Radon transform as

$Rf(\Theta, t) = \int f(x1, x2,)\, \delta(x1\cos\Theta + x2\sin\Theta - t)\, dx_1\, dx_2$…….(2)

then the ridgelet transform is the application of a 1-Dwavelet transform to the slices (also referred to as projections) of the Radon transform.

$CRTf(a, b, \Theta) = \int \Psi_{a,b}(t) R_f(\theta, t) dt$………………………….(3)

For $f \in L1(R2)$ is represented as a continuous superposition of Ridgelet coefficient and is given by

$Rf(a, b, \Theta) = \int f(x)\Psi a, b, \Theta(x) dx$ ……………………..(4)

Any Function $f \in L1(R2) \cap L2(R)2$ is represented as a continuous superposition of Ridgelet functions.

$F(x) = \iiint R_f(a, b, \theta)\Psi a, b, \theta(x) da$………………………..(5)

A. Discrete Ridgelet Transform

A continuous ridgelet transform is calculated by applying 1D wavelet transform to the slices of radon transform $R_f(\theta)$. In radon transform a famous projection-slice theorem is used. This theorem says that the Radon transform can be obtained by applying the one-dimensional inverse Fourier transform to the two-dimensional Fourier transform of function restricted to radial lines through the origin. The relation among the Fourier, radon and ridgetet domain is depicted shown in Fig. 1.

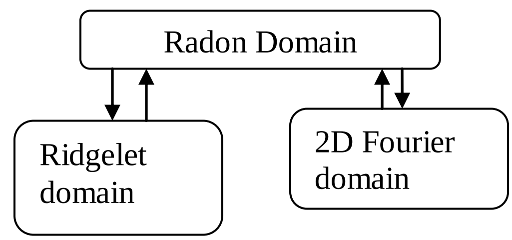


Fig .1 Relations between Domains

To complete the ridge let transform, apply a one dimensional wavelet transform along the radial variable in Radon space. The sum up of above procedure is shown in Fig. 2 in the form of flow chart. The DRT of an image of size $n\times n$ is an image of size $2n\times 2n$,introducing a redundancy factor equal to 4 [25,26].

$F(\omega\cos\theta, \omega\sin\theta) = \int R_f(\theta, t) e^{-2\pi i\omega x} dt$ ………………..(6)

B. Multiscale Ridgelet Transform

Multiscale ridgelets based on the ridgelet transform combined with a spatial bandpass filtering operation to isolate different scales .

Algorithm

- Apply a trous algorithm with M scales
- Apply Radon Transform on detail sub - bands of M scales.
- Calculate the ridgelet coefficients by applying
- 1D wavelet transform on radon coefficients.
- Get the multiscale ridgelet coefficient of M scales.

III. FAST INDEPENDENT COMPONENT ANALYSIS

Independent component analysis is a method of signal processing and used for data analysis. It is based on blind source separation (BSS) method. Without the source signals the coefficients are used for the recovery of the signal.ICA was introduced by Comon, Pierre [16]. Hyvarinen proposed famous Fast ICA based on negative entropy principle [17].

A. The Mixing Model of ICA

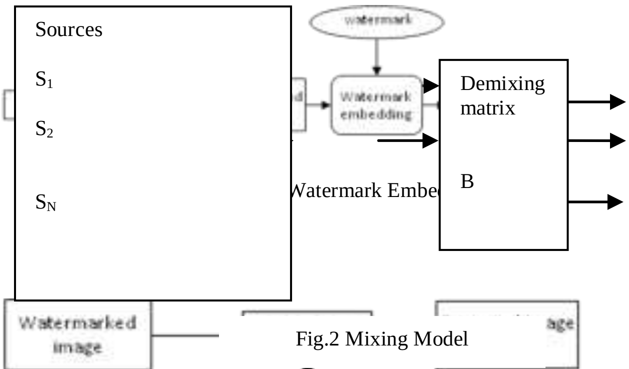


Fig.2 Mixing Model

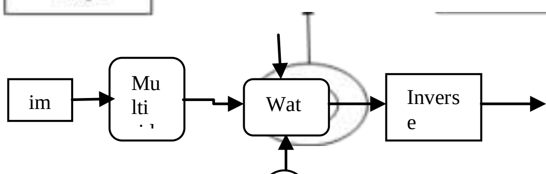
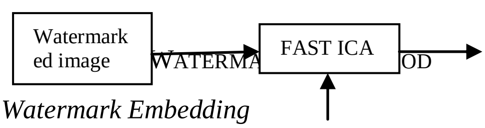


Fig.4 Watermark Extraction



B. Watermark Embedding

In the proposed method ,the image and watermark is decomposed by multiscale ridgelet transform. The coefficients of mulriscale ridgelet for watermark imageW_{MR} is embedded in the low resolution part of the image I_{MR}

I_{MR} (low) = I_{MR} (low) (1+αW_{MR} (low)) ....(7)

From the spectrum analysis of the image most of the useful information is located in the low resolution part of the image. The invisibility of watermark is enhanced by using proper value for α. On the contrary, in case of attacks low resolution part of the image is preserved in the low representation of the image ,making the watermark robust.

The other coefficients are embedded in the high frequency components of the image representing the edges and textures. To increase the robustness of the watermark we use the equation

I_{MR}(hi)= I_{MR}(hi) + βW_{MR}(hi) ....(8)

To maintain the invisibility of the image.

C. Watermark Extraction

For extraction process Fast ICA is used.

1. Before applying fast ICA the input vector data should be centered.
2. The data should be centered by computing the mean of each component of X and subtracting that mean. This has the effect of making each component have zero mean.

$$X \leftarrow X-E(X)$$

3.The iterative algorithm finds the direction of weight vector W maximizing the non-gaussianity of the projection $W^T X$ for the data X.

4. Randomize the initial weight vector W.

5. let

$$\mathbf{w}^+ \leftarrow E\{\mathbf{x}g(\mathbf{w}^T\mathbf{x})\} - E\{g'(\mathbf{w}^T\mathbf{x})\}\mathbf{w}$$

6. Let $\mathbf{w} \leftarrow \mathbf{w}^+/\|\mathbf{w}^+\|$

7.If not converged go to step 5.

C. Quality Measures of proposed method

Any new method is evaluated based quality measures. For this new method we have used four quality measures.

i)Mean Square Error

MSE =

$$\frac{1}{M \times N}\sum_{X=0}^{M-1}\sum_{Y=0}^{N-1}(f(x,y)-z(x,y))2$$ ....(9)

ii) Peak Signal to Noise Ratio

The ratio between the maximum power of a signal and the power of corrupting noise .It is defined via the mean squared error for which two I*J images f and z where one of the images is noise and the other is given as

PSNR is given by

$$PSNR = 10log\,10\frac{\sqrt{MaxB}}{MSE}\ dB$$ ....(10)

iii) Structural Index Similarity Measure(SSIM)

The extracted watermarks can be compared with original watermark subjectively. Beside subjectively judgment for the watermark fidelity, we have defined an objective measure of similarity between the original watermark and the extracted watermark in the following way:

$$SSIM = \frac{\sum_i\sum_j w(i,j)\tilde{w}(i,j)}{\sum_i\sum_j[(\tilde{w}(i,j)]2}$$ ....(11)

V. CONCLUSIONS

The computer tomography, MRI and ultrasound images are taken and watermarked. We have taken 50 images in ...age and studied. The Gaussian, rotation, scaling, ... pepper noise and speckle noise are added and ...k to signal noise ratio is calculated. The corresponding structural similarity index and mean square error are also calculated and found to be significantly higher. So we can conclude that a above method gives a acceptable result when compared with the previous techniques.

PERFORMANCE MATRICES

TABLE 1: FOR CT IMAGES

CT Images	PSNR	MSE	SSIM
IMAGE1	59.2181	0.0779	0.9979
IMAGE2	58.5565	0.0907	0.9973
IMAGE3	58.5229	0.0914	0.9973
IMAGE4	8.5978	0.0898	0.9972
IMAGE5	59.7017	0.0696	0.9981

TABLE II: FOR MRI IMAGES

MRI Images	PSNR	MSE	SSIM
MAGE1	67.9157	0.0105	0.9997
IMAGE2	71.3853	0.0047	0.9996
IMAGE3	71.1752	0.0050	0.9989
IMAGE4	69.9087	0.0066	0.9997
IMAGE5	67.9319	0.0105	0.9997

TABLE III: FOR MRI IMAGES

ULTRA Images	PSNR	MSE	SSIM
IMAGE1	80.4523	0.0006	0.9993
IMAGE2	72.3905	0.0037	0.9998
IMAGE3	70.4234	0.0059	0.9996
IMAGE4	70.6903	0.0055	0.9990
IMAGE5	77.1617	0.0013	0.9990

TABLE IV: COMPARISONTABLE

TABLE V: EFFECT OF DIFFERENT NOISES ON DIFFERENT IMAGES

No	tacks	PSNR		SSIM	
		T (Lena nage) ef 18	T(Medic nage) oposed	T (Lena nage) ef 18	T(Medic nage) oposed
1.	Gaussian	22.32	67.9985	0.9001	0.9265
2.	Rotation	23.18	66.9370	0.8764	0.9316
3	Scaling	-	66.9895	-	0.9316
4	Salt and pepper	21.29	67.5509	0.8884	0.9297
5	speckle	-	67.7110	-	0.9419

Ct images	PSNR	MSE	SSIM
Gaussian	56.4556	0.0798	0.9046
Rotation	56.4679	0.0773	0.9597
Scaling	55.4093	0.0793	0.9505
Salt and pepper	57.2532	0.0792	0.9791
speckle	56.2267	0.0787	0.9754

MRI images	PSNR	MSE	SSIM
Gaussian	67.9985	0.0032	0.9265
Rotation	66.9370	0.0026	0.9316
Scaling	66.9895	0.0027	0.9316
Salt and pepper	67.5509	0.0002	0.9297
speckle	67.7110	0.0001	0.9419

ultra images	PSNR	MSE	SSIM
Gaussian	72.3957	0.0023	0.9934
Rotation	72.8094	0.0029	0.9475
Scaling	70.9152	0.0002	0.9162
Salt and pepper	72.0169	0.0006	0.9009
speckle	72.8900	0.0026	0.9724

SCREEN SHOT:

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