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Development of a New Blind Watermarking for Medical Images

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Abstract: Securing the data of patient and keeping the information confidential has become a challenging task at present days. More number of chances are available for information alteration or security breach. When the information is transferred from source to destination digital image watermarking technique is most commonly used to secure the patient's information watermarking provides the copy right protection, authentication proof and detection of tampering. This paper presents a watermarking technique to embed patient's information in a medical image so that information can be transferred securely and information alteration would be prevented. An Arnold Chaotic Map is applied to the sensitive watermark image to scramble the pixels in the sensitive watermark image. The cover medical image is partitioned into non overlapping blocks and DCT is applied to each block. Each and every bit of the watermark image is embedded into block by using Weber Descriptor. By using this Weber Descriptor robustness of an image will be increased. An experimental result shows that the proposed algorithm improves the robustness against various attacks like compression, filtering and noising.

Keywords: watermarking, DCT, Arnold Chaotic map, Weber descriptor, robustness

I. INTRODUCTION

At present, computer networks and multimedia are the latest and rapidly developing technology and is creating a huge impact in the society. Moreover, further we have many advance techniques in image processing, most of the mechanisms are existed but we are dealing with the image watermarking from those mechanisms. Watermarking is nothing but a transparent image or a text is embedded into a piece of paper or into another image. In these days, watermarking is very important in our lives because it is used to protect the original image or the data contained in the original image and also make difficult for others to copy the data contained.

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Watermarking is mainly used to embed the information so that the information is not shown and it is also safe from alteration. The classification of watermarking techniques depends on the domain and extraction process.

Watermarking technique has three categories they are semi-fragile, fragile and robust. Robustness watermarking shows resistance against any kind of transformations on the images that are watermarked. In a semi-fragile watermarking technique, the embedded information remains safe and constant irrespective of some operations performed on it like compression, filtering, noising
etc…. and this is sensitive to the tampering operations. It certifies the authenticity and integrity of the data. We can clearly notice the fragile watermarking when there occurs minute changes. If any are done in the original image, they can be clearly understood. Robustness is not constrained for general operations. They are adding noise filtering, A/D or D/A conversion, compression. It is mostly used for geometric attacks such as scaling translation, shearing, rotation and also used in protection of ownership. As it is mentioned above that the classification done based on the extraction process, the watermarking techniques are classified as Blind, Semi-blind and Non-blind. Blind watermarking is a technology that, it doesn't need any original image or any other characteristics in the image extraction. For the semi-blind watermarking technique, watermark is for detecting the watermark and also watermark bit sequence, secret key are used. Non-blind watermarking is another technique, it uses original image to detect and extract the watermark. The classification which is based on the domain, then they can be tabulated into spatial and frequency watermarking techniques. Spatial watermarking techniques are operated on image pixels so that the computational process number is less. But with these techniques we cannot get the required robustness. Frequency watermarking techniques depends on the data obtained from transform coefficients they are Discrete cosine transform DCT , Discrete wavelet transform DWT, Discrete Fourier transform DFT, Singular value decomposition DVD as these favour low frequency components, provides more robustness. Irrespective of development in technology, the technique of watermarking is facing a lot of challenges. The challenges that are included are choice of watermarking technique speed, design considerations, robustness, requirement analysis.

Imperceptibility is nothing but, the perceived quality of host image should not get disturbed when the watermark is present.

The watermark should be imperceptible to the human observation when the host image is embedded with the secret data. Better security exists as the digital information is hiding in the carrier signal and there is no need to have a relation between the carrier signal and the hidden information.

In order to secure the electronics patient's information and the recorded data, this paper is presenting a new watermarking technique known as Block-based watermarking. This watermarking mainly aims in combination with discrete cosine transform, weber descriptors, Arnold chaotic map. Firstly, DCT is mostly used in image processing and in the signal area. This is mostly used, particularly when the middle-band coefficients are imposed as like as an embedding area for increasing the imperceptibility and robustness. Secondly, use of WD's helps us a fast and easier technique for embedding and blind extraction process.

Finally, by using Arnold chaotic map we are able to scramble the watermarked image. This helps us to protect the watermark among several encryption techniques. The remaining paper is formulated as; The second part is all about the related work and third part consists of foundation and basic requirements and the fourth part consists of proposed blind watermarking method and fifth session deals with the result and finally, last session consists about the conclusion

II. RELATED WORK

In the previous years, a greater number of techniques on watermarking has come into an existence [1 – 5]. Most of the authors have given about an algorithm called semi-blind for delicate images in text established on YUV transforms and DCT. The initial task is to execute YUV transform for both cover images and watermark, after applying DCT on Y block then separate the coefficients of each matrix with the matrix quantization. At the finishing stage, the evaluated watermark matrix is ceiled in the cover image evaluated matrix. From the experimental results, it is proved that, it has obtained the imperceptibility and also the robustness is good. The major drawback of this approach is that more execution time for embedding or extraction process.

Singh et al. [6] have given many methods for watermarking on medical images depending upon discrete cosine transform DCT, discrete wavelet transforms DWT, and SVD. When the embedding process is going on, cover image is decomposed with DWT. Later SVD and DCT are applied to the watermark which is encrypted and on the host image of LL band. The encrypted watermark of the singular values is embedded with the host image singular values. Along with this, in HH band the second watermark is embedded. This approach gives tremendous improvement in robustness, embedding security and capacity features, not only that but also it has certain restrictions concerning about the medical image imperceptibility (PSNR value = 33dB or CT-scanning images). Also, it needs huge prominent complexity in computational part.

Mansoori et al.[7] have stated a method based on the bordered Hadamard transform OHT. Main aim behind this is the decomposition of the watermark and the host image into blocks. After this OHT is applied to both of them and then the substitution of coefficients with high frequency with the host image and also with the coefficients of watermark with the host is done. The major advantage of this approach is that, it gives a high robustness, computational complexity and good imperceptibility. However, it has one disadvantage that it is fragile to few offensives like JPEG compression (PSNR= 16.73db) and normalized coefficient (NC=0.79) and the salt and pepper noise(PSNR = 11.17 dB) and (NC=0.75) and there is no protection against the watermark. The writers [41] have given a technique based on DWT, SVD, DCT called hybrid technique. In this technique, using four bit MSBs and four bit LSBs of each pixel, the watermark is divided. Then we apply DCT to two parts. Later the application of DCT to both the parts, the coefficients of DCT are scrambled and embedded into singular value of the DWT sub bands of the host image. Hence, it provides great improvement in watermark imperceptibility and also in robustness, also there are various limitations like calculation time is high, and it has susceptibility against geometric offensives like rotation attack 45̊(NC = 0.5184) .

Ghadi et al. [8] depending upon the jacobian matrix, he has given a new technique about the robustness and imperceptibility in the watermarking. Main initial task is, by using the average intensity of 8 8 blocks, a relevant watermark is constructed with the arrival of the jacobian matrix. The technique provides more robustness and imperceptibility. The limitation if this technique is that, without the encryption of watermark, it works only in the domain of spatial and it requires a enormous prominent computational complexity. The writers [9] have given a technique called blind technique found on DCT, Arnold chaotic map, repetition code RC. The main design is to dissolve the components of green and blue of the host image into blocks. Later, we apply DCT to every block particularly. At last, we scramble the watermark with Arnold chaotic map and at the middle band coefficients the RC bit is embedded. This technique provides great imperceptibility, robustness and security. It has a drawback that is, execution time is required. Also, with few attacks the initial watermark gets damaged. The attacks are salt and pepper noise, Gaussian noise (BER > 10%) , (density =0.03) (BER = 12%) , (cropping 256× 256),(BER 12.8).

Some techniques of watermarking are used for computer vision. The authors[10] have given a technique based on DWT is semi-blind technique. Balanced neural tree BNT and SVD. Basic idea is, apply DWT on the host image and then on the LL band apply SVD and make BNT to determine the watermark. Then to embed, we scramble the synapses of the trained BNT and then embedded in a singular values computed lower. The advantages of this technique is that, a good robustness and a security imperceptibility is provided. The major drawback is, it requires a more amount of time for execution in extraction/ embedding process.

Based on DCT [11]and artificial bee colonies ABC, writers have given a blind technique. The basic of this is to apply DCT to the host image of each block and then from the two groups of the pre-determined locations select the positions of the coefficients.

In order to go for embedding step, we need to calculate the absolute difference between the two coefficients because to know either it provides robustness or not. In order to search the optimum scaling factor, a new fitness function is proposed based on ABC.

Experimental factors show that it provides good robustness. But the disadvantage is that it takes more time for execution and also there is no security for the watermark. Mainly, watermark is prone to few attacks like rotation , Gaussian noise attack(BCR <64%),rotation (0.5̊ and 0.75̊) (BCR <62%), average filter (7×7 and 9×9)(BCR <65%),median filter (9×9)(BCR <53%).

Moghaddam et al.[12] using imperialist competitive algorithm ICA given a method in spatial domain. Basic idea is to convert watermark and host image into vectors. Then, in order to position the watermark insertion in the best locations we use ICA.

Later to this, we choose an embedding location depending upon the least significant colour in neighbourhood of each pixel. In order to do the process of embedding, based on some parameters, the selected pixel intensity values are changed. They are the average neighbour's intensity values, embedding parameters and the watermark bits.

Results have shown that, it provides good imperceptibility and good robustness. But the drawback is that this approach needs a huge amount of execution time and the capacity of bedding is low.

A technique[13] about robust was given by the writers using DCT and probabilistic neural network (PNN).

To do the embedding process, the coefficient blocks and the watermark binary blocks are embedded after applying DWT and for extraction process, in order to obtain the data of the watermark we use the DWT coefficient blocks as an input to the trained PNN.

From the results, it is evident that it provides good embedding quantity, robustness and imperceptibility.

But it has a disadvantage that, after JPEG compression the watermark which is extracted its quality is not good(NC value <0.75)and this method needs large amount of computational complexity.

III. FOUNDATION AND BASIC REQUIREMENTS:

A. Discrete Cosine Transform (DCT):

Discrete cosine transform is used to express the sequences whose data points are finite, sum of cosine functions and it is oscillated at distinct frequencies.

Discrete cosine transform is popularly known as frequency domain watermarking and it divides the carrier signal into three frequency bands.

They are high frequency band, middle frequency band, low frequency band. It gives more robustness and also it is robust against some image processing operations like filtering, brightness etc., and also it has a capability to convert the image into equivalent frequency components.

B. Weber Law Descriptors (WDs):

Weber law descriptor states that when there occurs any changes in the stimulus, that will be noticed is a constant ratio of the original stimulus.

The relation between the intensity and quantity is represented by weber law descriptor. This weber law consists of two descriptors, namely differential excitation (χ) and orientation(λ)

Differential excitation is a function of ratio between two terms

1.relative intensity differences of its neighbors against to a current pixel

2. intensity of the current pixel

Orientation component is the gradient of an image and which does not properly represent local spatial information of an image.

$$\Delta I/I=K$$

Where ΔI represents the increase in threshold.

I represent the initial stimulus intensity.

Pixels differential excitation is that the relative difference to its neighbors intensity, this can be represented as

$$\chi(i , j)=\arctan(\sum_{n=0}^{m-1} P(n) - P/P)$$

where m is the neighbor of P, and i and j are the pixel P coordinates.

where orientation is the current pixel gradient orientation. This can be calculated

by using various neighbour in different angles. Orientation is represented as

$$\lambda(i, j) =\arctan\left(\frac{S\ (i+4) - S\ (i)}{S\ (i+6) - S\ (i+2)}\right)$$

where i={0….n/2-1}

C. Arnold Scrambling

Arnold chaotic map, in this the pixels of an image will be scrambled means changes the location of each pixel for generating the new image with the small size of an original image and these are rearranged.

When there is a transformation occurred to the scrambled image then we get the original image**.**

$$\begin{bmatrix} i' \\ j' \end{bmatrix}=\begin{bmatrix} 1 & 1 \\ 1 & 2 \end{bmatrix}\begin{bmatrix} i \\ j \end{bmatrix} \text{mod N}$$

where i, j are the original image pixel coordinates

where I', j' are the scrambled image pixel coordinates and N is the size of the watermark.

We will get the inverse of the scrambled image with the following equation

$$\begin{bmatrix} i \\ j \end{bmatrix} = \begin{bmatrix} 2 & -1 \\ -1 & 1 \end{bmatrix}\begin{bmatrix} i' \\ j' \end{bmatrix} + \begin{bmatrix} N \\ N \end{bmatrix} \text{mod N}$$

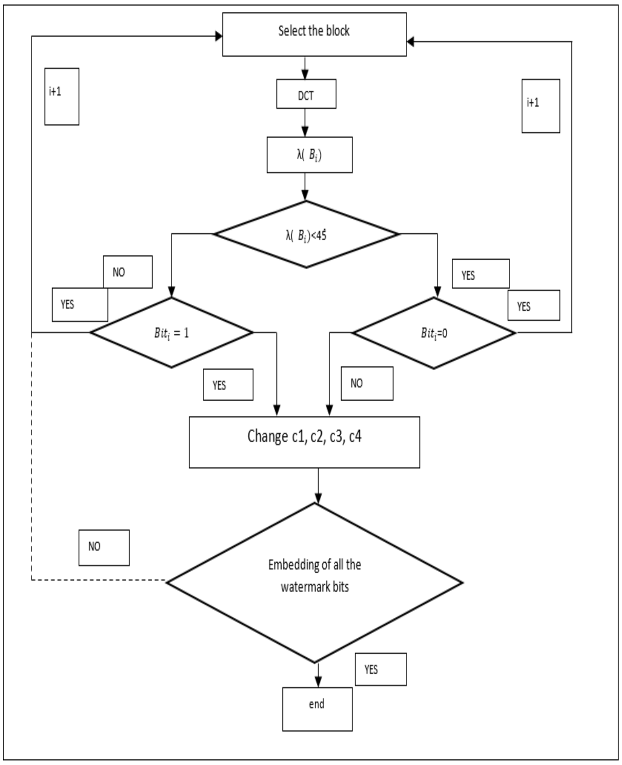

Fig 1.1 Embedding flow chart

D. Pre- processing Phase:

The beginning phase of the watermark embedding process can be done by following the below procedure:
Step 1: consider a medical image.
Step 2: In order to protect the quality of an image, taken image is divided into Non-overlapping blocks with 4×4 pixel size. On each and every block one watermark intensity bit is embedded.
Step 3: Scrambling of the binary watermark image is to be done by using Arnold chaotic map in order to secure the watermark data.

E. Proposed Blind Watermarking Method:

In this section we propose watermarking method. It consists of two processes: watermark embedding process and the watermark extraction process. Our main goal is to increase the robustness without affecting the image quality.

IV. EMBEDDING PHASE:

A. Watermark Embedding Process:

Embedding procedure of watermark uses the images of grayscale. This procedure is composed of embedding the scrambled binary watermark. This procedure is successfully brings out in two stages, they are pre-processing phase and embedding phase.

B. Processing phase:

Pre-processing phase is followed by processing phase. The processing phase is done by following the below procedure
Step 4: One of the blocks is selected and DCT is performed on it. Then from the coefficients of middle band select four coefficients c1,c2,c3,c4. We embed the coefficients of watermark intensity by using these four coefficients.
Step 5: Calculate the orientation (λ) of Bi by using

$$\lambda(Bi) = |\, Arctanc(c1 - c2 / c3 - c4)|$$

Step 6: Select an intensity from the scrambled binary watermark and embed it according to the following cases:
Case 1:Biti = 1 and λ(Bi) < 45◦; in this case, the values of c1, c2, c3, c4 are modified as follows:
Permute (c1, c3).
Permute (c2, c4).
c1 = c1 + K.
where K is an embedding strength used to reinforce the
where K is an embedding strength used to reinforce the watermark presence.
Case 2: Biti = 0 and λ(Bi) ≥ 45◦; in this case, the values of c1, c2, c3, c4 are modified as follows:
Permute (c1, c3).
Permute (c2, c4).
c3 = c3 + K.
Other case: go to step 7
Step 7 : Perform the DCT inverse on Bi . If not all the watermark bits are embedded back to step 4 withi=i+1.

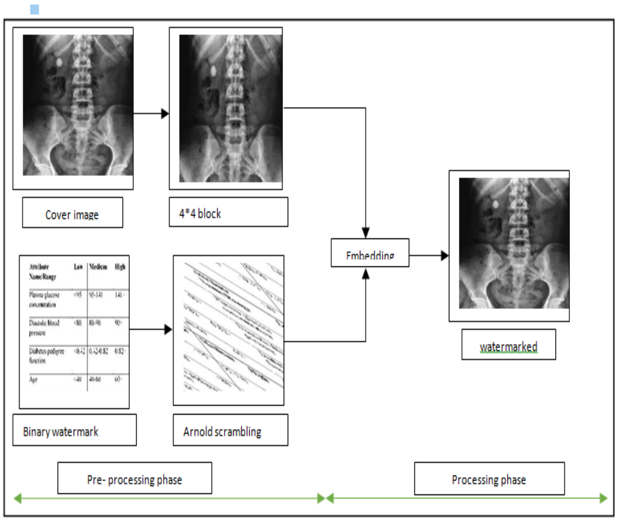

Fig 1.2 embedding process of watermarking

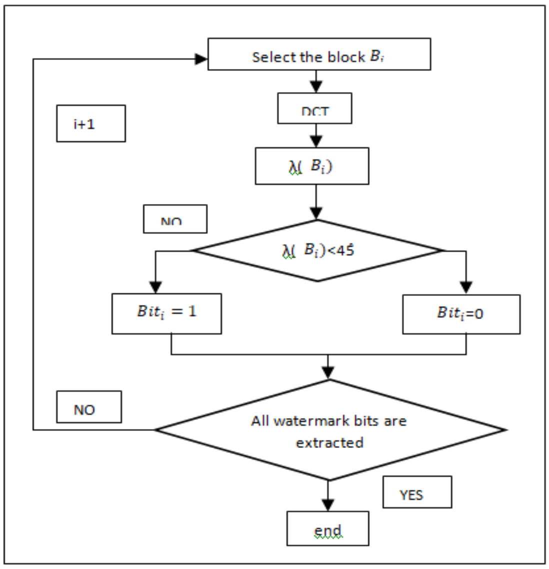

Fig 1.3 flow chart of extracting process

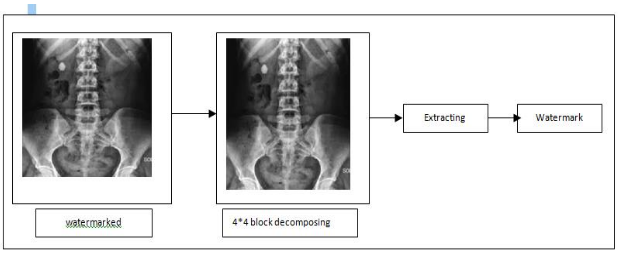

Fig 1.4 extracting process of watermarking

V. EXTRACTING PHASE:

A. Watermarking extracting phase:

Step1: Consider a medical image,
Step 2: In order to protect the quality of an image, taken image is divided into Non-overlapping blocks with 4×4 pixel size. On each and every block one watermark intensity bit is embedded.
Step 3: One of the blocks is selected and DCT is performed on it. Then from the coefficients of middle band select four coefficients c1, c2, c3, c4. We embed the coefficients of watermark intensity by using these four coefficients.
Step 4: The orientation of Bi is calculated by using
λ(Bi)Arctanc(c1 − c2 /c3 − c4)|
Step 5:From the following cases we can extract the bit Biti of the scrambled watermark.
Case 1 λ(Bi) < 45◦, in this case Biti = 0.
Case 2 λ(Bi) ≥ 45◦, in this case Biti = 1.
Step 6: Then the inverse DCT is performed Bi .If the extraction of all the bits on watermark is done to step 7, else go back to step 3 with i = i + 1
Step 7:For getting the original watermark image, apply inverse Arnold scrambling to the watermark which is extracted.

VI. EXPERIMENTAL RESULTS AND DISCUSSION

we conducted simulations on Gray scale medical images of size 256×256. The binary watermark image is of size 32×32 in which each pixel is represented by either bit 1 or bit 0 (where bit 0 for black and bit 1 for white).
The proposed method is implemented by using MATLAB R2019b (Version 9.7)
In these simulation results, we calculated Peak Signal to Noise Ratio (PSNR) between the cover image and watermarked image.
This PSNR evaluates the imperceptibility of our proposed method. The imperceptibility measures the degree of similarity between the original image and the watermarked image.
The PSNR is calculated by evaluating Mean Square Error (MSE). The equations for MSE and PSNR are given by the 1.1 and 1.2 respectively

$$MSE = \frac{1}{N \times M} \sum_{j=0}^{N-1} \sum_{k=0}^{N-1} \left(I_1\,(j,k) - I_2\,(j,k)\right)^2 \qquad eq(1.1)$$

$$PSNR(dB) = 10 log_{10} \left(\frac{255^2}{MSE}\right) \qquad eq\ (1.2)$$

Where, I_1 and I_2 represent cover image and watermarked image respectively. The PSNR values between the cover image and watermarked image and embedding capacity are summarised in the table 1.1
Table 1.1 PSNR values between the cover image and watermarked image and embedding capacity of proposed method

Table 1.1 PSNR values of different images

Watermarking image	PSNR	Embedding capacity
Letter 'R'	42.05 dB	0.0625
Patient data	41.28 dB	0.0625

From the table, it is very clear that the PSNR values largely exceed 41 dB and the embedding capacity is 0.0625 which is a sufficiently large number i.e., one bit is embedded in i6 bits. The cover image, watermarking image, scrambled image, watermarked image and retrieved image are shown fig 1.5, 1.6, 1.7, 1.8 and 1.9 respectively when the watermarking image is a letter 'R' and fig 1.10, 1.11, 1.12, 1.13 and 1.14 show the cover image, watermarking image, scrambled image, watermarked image and retrieved image respectively when the watermarking image is a patient data. From these figures it is very clear that the retrieved image is almost resembles watermarking image.

Fig 1.5 Cover image

Fig 1.6 Watermarking Image

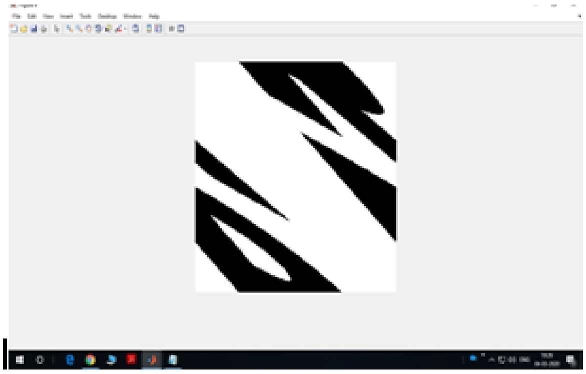

Fig 1.7 Scrambled Image

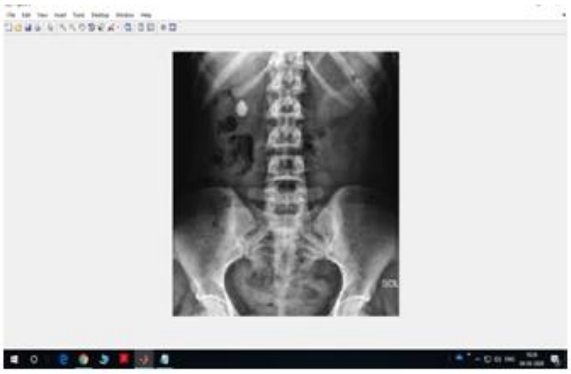

Fig 1.8 watermarked image

Fig 1.9 Retrieved Image

Fig 1.10 Cover Image

Attribute Name/Range	Low	Medium	High
Plasma glucose concentration	<95	95-141	141<
Diastolic blood pressure	<80	80-90	90<
Diabetes pedigree function	<0.42	0.42-0.82	0.82<
Age	<40	40-60	60<

Fig 1.11Watermarking Image

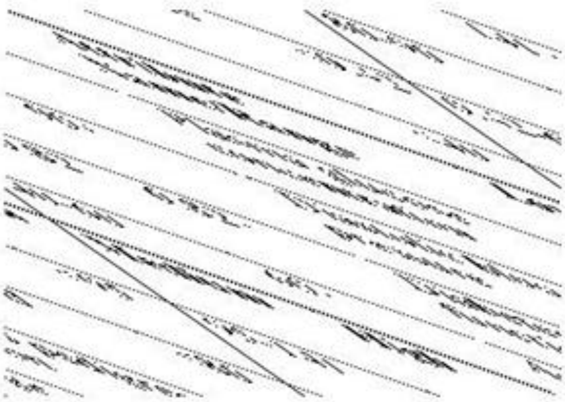

Fig 1.12 Scrambled Image

Fig 1.13 Watermarked Image

Attribute Name/Range	Low	Medium	High
Plasma glucose concentration	<95	95-141	141<
Diastolic blood pressure	<80	80-90	90<
Diabetes pedigree function	<0.42	0.42-0.82	0.82<
Age	<40	40-60	60<

Fig 1.14 Retrieved Image

VII. CONCLUSION AND FUTURE WORK

In this project, we presented a new watermarking technique is developed which embeds the patient's information in a medical image. The watermarked image is transmitted securely such that the patient's information can be retrieved by actual known persons only. In order to enhance the security, the watermarking image is first scrambled and then embedded.

This project embeds one watermarking bit on 16 cover image bits i.e., a 4 x 4 block. A N x N watermarking image requires a 4N x 4N cover image. This is a major drawback of our project. This needs a development in the future works by embedding capacity.

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