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Dual Authentication Watermarking System in Tele-radiology using WBC Transform

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ABSTRACT:Tele-radiology is a vibrant field in the stream of medical diagnosis in which maintenance and transmission of the medical reports like MRI,CT-Scan and X-Ray can be done through internet. The main objective of Tele-radiology is automated report handling of the patients and getting best opinion of the doctors around the world by proper authorization. The issue arises at verification, validation and encryption of the medical images sent through the internet. To address the issue of verification, in this paper we have used dual authentication schemes, one is fingerprint authentication which has been implemented using Minutiae Method and the other is IRIS Authentication through Trapezoidal Normalization. The validation of medical images authenticates the patient medical data through their credentials and this process is addressed by using watermarking methodology implemented through wavelet based counter let transform (WBC). The encryption of the image is done prior to verification and validation of the image using randomization methodology. The efficiency of watermarking methodology is verified with PSNR,MSE and Correlation Coefficient, significant improvement is observed in proposed methodology.

KEYWORDS: Trapezoidal Normalization, Randomization, wavelet based contour let Transform(WBC), Minutiae method, IRIS Authentication, Tele-radiology, encryption.

I.INTRODUCTION

Evolution of globalization and usage of internet has emerged an E-Health Management System in which the diagnosis and analysis of the treatment of the diseases is done through the internet. Tele-radiology is one among the hierarchy of the E-Health Management System. The process of Tele-radiology involves in sending and receiving the medical images like X-Ray, MRI, CT Scan through a separate mail management system in the internet[1]. Here in the process of sending images may undergone fraud tampering, unauthenticated usage[1] of image without any right. To get rid of this problem in this paper we proposed a dual authentication scheme for verification of valid user and validation of the patient data is achieved through watermarking scheme introduced in the medical image. Finest dual authentication schemes are proposed in this paper such as finger print authentication using Minutiae method[2], which is the best finger print recognition which is purely based on the minutiae points that represents the local geometrical features like terminations and bifurcations. The other authentication is IRIS based on Trapezoidal Normalization prior canny edged detection, circular Hough transform are used for segmenting the image. Feature encoding is done through the 2-D Gabor filter, encoded iris code is obtained by Reed Solomon code.

Watermarking the patient data into the Biomedical image is an efficient mechanism that handles the hands free report carrying to the patient and validates the patient details before analyzing their medical image . In the process of watermarking , decomposition of the image to get an appropriate sub-band is an important procedure since decomposition, selecting appropriate sub-band and inserting the patient details into the sub band should not affect the visual information of the original image, so we addressed above problem using wavelet based contour let transform (WBC). Prior to this method wavelet and contour let transforms were used which are not capable to handle the 2-D singularities of the image and having redundancy factor of 4/3 respectively , so used WBC in which wavelet transform is applied first then contour let transform is applied to achieve the quad tree decomposition of both low pass and high pass channels. The PSNR,MSE and Correlation coefficient (CC) are compared for respective decomposition methodologies as shown in the Table I, Table II and Table III.

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II.FINGER PRINT RECOGNITION (MINUTIAE METHOD)

Finger print recognition consist of two process such as enrollment and identification of fingerprint[2].In this paper we used Minutiae method for finger print recognition. The minutiae based techniques represent the fingerprint by it's local features like terminations and bifurcations. If two Minutiae points are matched then finger print of the person is said to be identified.

The fingerprint can be represented in three levels[3]

- **Global Level:**

It is pattern which is an aggregate characteristics of ridges and minutiae points.

- **Local Level:**

Unique features like small points with in a small pattern is represented.

- **Very Fine Level:**

small point which is called minutiae points are represented.

The three representations are shown in below figures

Fig 1**:** Global Level

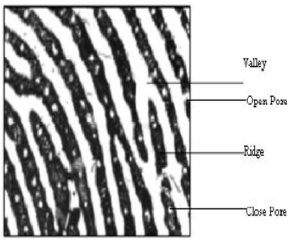

Fig 2: LocalLevel

Fig 3:Very Fine Level

Block Diagram of the Minutiae method is depicted below

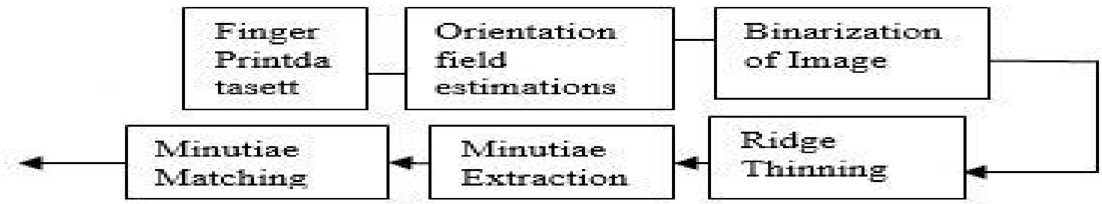

Fig 4:Finger Print Recognition Process

Fingerprint dataset: In this step finger print dataset in the format of jpeg file is loaded for further processing.

Orientation field Estimation: The finger print image is preprocessed for the image enhancement by convolving the image with gabor filters tuned to the local ridge orientation and frequency.

Binarization of the Image/Enhancement: It converts gray scale fingerprint image to binary image by fixing threshold value. If the pixel value is above threshold it is set to '1'. If the pixel value is below threshold it is set to '0'.

The enhanced view of the original loaded fingerprint image and modified images is depicted below.

Fig 5::(a)Original Fingerprint image (b)Enhanced Image/Binarized image

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Ridge Thinning:

Block filter is used for the ridge thinning of all ridges to a single pixel width to extract minutiae points effectively. Thinning will not change the orientation and location of minutiae points compared to original image. Thinning and original images are depicted below.

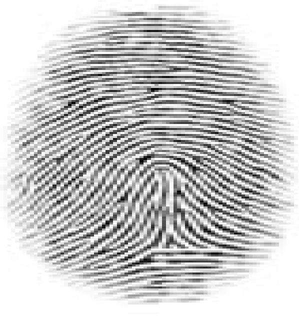
Fig 6:(a)Binarized Image (b) Thinned Image

Minutiae Extraction:

Minutiae location and angles are derived in this method. The crossing numbers are used to locate the minutiae points in the fingerprint image. Crossing can be defined as half of the sum of the difference between intensity values of two adjacent pixels if crossing numbers is 1,2 and 3 or greater than 3 the minutiae points are classified as terminations, normal ridges and bifurcation[4] represents as shown in figure 7

Fig 7:(a) Ridge Endings (b) Bifurcations

Termination angle is calculated by considering the termination and bifurcations of the image



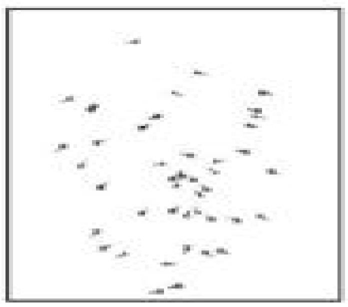


Fig 8 :(a)Gray Scale Finger Print (b) Minutiae Points

Minutaie matching:

To compare the input finger print data with enrolled finger print data minutiae it is stored in a matrix format

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$$\begin{array}{l} \\ \text{Menutiea-1} \\ \text{Menutiea-2} \\ \text{Menutiea-3} \\ \quad ; \\ \quad : \\ \\ \\ \text{Minutiae-N} \end{array} \begin{array}{c} \begin{array}{cccc} \text{Col-1} & \text{Col-2} & \text{Col-3} & \text{Col-4} \end{array} \\ \left[\begin{array}{cccc} & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \end{array} \right] \end{array}$$

column-1 represents the row index of each minutiae point
column-2 represents the column index of each minutiae point
column-3 orientation angle of each point
clolumn-4 Type of minutiae
1 for Termination
3 for bifurcation

In matching process each minutiae point is compared with enrolled minutiae point. In every case enrolled and input minutiae are selected as reference points for respective data sets. The reference points used to compute remaining data points as polar coordinates as shown below.

$$\begin{pmatrix} r_k^T \\ \phi_k^T \\ \theta_k^T \end{pmatrix} = \begin{pmatrix} \sqrt{(row_k^T - row_{ref}^T)^2 + (col_k^T - col_{ref}^T)^2} \\ \tan^{-1}\left(\dfrac{row_k^T - row_{ref}^T}{col_k^T - col_{ref}^T}\right) \\ \theta_k^T - \theta_{ref}^T \end{pmatrix}$$

For enrolled image

the data points are converted intopolar coordinates as shown below

$$\begin{pmatrix} r_m^I \\ \phi_m^I \\ \vartheta_m^I \end{pmatrix} = \begin{pmatrix} \sqrt{(row_m^I - row_{ref}^I)^2 + (col_m^I - col_{ref}^I)^2} \\ \tan^{-1}\left(\dfrac{row_m^I - row_{ref}^I}{col_m^I - col_{ref}^I}\right) \\ rotatevalues(k, m) \\ \theta_m^I - \theta_{ref}^I \end{pmatrix}$$

III.IRIS RECOGNITION (TRAPEZOIDAL NORMALIZATION)

Block Diagram of IRIS Recognition is as shown in figure 9. Iris feature extraction from the eye includes following stages

- Segmentation
- Normalization
- Encoding/Extraction

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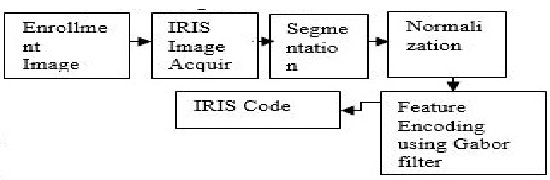


Fig 9: Iris Recognition Process

Segmentation

In segmentation there are two steps

Canny Edge Detection: It is used to identify the edges that are not connected to strong edges.

Circular Hough Transform: It is used find iris circles that differentiates the iris part with purple part.

Normalization

In this paper we used trapezoidal normalization[5] which is ideal normalization methodology to extract the iris information content in the eye with any setbacks. Prior to this Rectangular normalization was used but it has limitations like redundancy and losing the iris data.

Normalization can be defined as the process of remapping the image from Cartesian co-ordinates to polar co-ordinates. If the IRIS region is circular then normalized image is trapeze in shape if the iris is in elliptical then normalized image is skewed trapeze.

Trapezium strip is calculated based on below equations

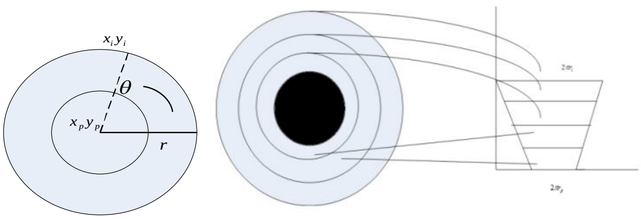
$$I_{norm}(r,\theta) = I(x,y) \Rightarrow r = \sqrt{\left((x-x_0)^2 + (y-y_0)^2\right)}\ r_p \le r \le r_i$$

$$\theta = \arctan\left(\frac{y-y_0}{x-x_0}\right) \Rightarrow \theta' = \theta . r + \left(\frac{2\pi r_i - 2\pi r}{2}\right) \quad ,0 \le \theta \le 2\pi$$

where $I(x,y)$=Image Intensity Function in Cartesian coordinates.

$I_{norm}(r,\theta)$=Normalized Trapeze Intensity Function in Polar Co-ordinates

schematic of mapping the iris content trapeze strip is as shown below



Feature Encoding:

In this step normalized image (Trapeze image) is encoded to digitized code. This code is used to compare with enrolled iris content the 2-D gabor filter is used to extract the frequency components of iris effectively 2-D gabor filter convolution with iris normalized image is based below equation.

$$h_{(\mathrm{Re,Im})} = \mathrm{sgn}_{(\mathrm{Re,Im})} \int_\rho \int_\phi \left(I(\rho,\phi) e^{-j\omega(\theta_0-\phi)} e^{-\left(\frac{(r_0-\rho)^2}{\alpha^2}\right)} e^{-\left(\frac{(\theta_0-\phi)^2}{\beta^2}\right)} \right) \rho d\rho d\phi$$

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where

$I(\rho,\phi)$ =Normalized Image in Polar Coordinates.

α and β are the multi scale 2D wavelet Size parameters.

($r0$, $\theta0$) are the polar coordinates of each region of iris.

ω is the wavelet frequency.

Wavelet Based Contour Let Transform(WBC)

The validation of patient details is addressed by watermarking. In the process of watermarking, decomposition of image into sub-bands is an important procedure which is implemented by applying WBC transform. Prior to WBC transform there were two widely used transforms one is Harr-Wavelet and other is contour let based. The Harr-Wavelet has limitations in finding decomposition levels and 2-D Singularities of the image, to alleviate these limitations Contour let Transform was used which is an efficient transform in representing the two dimensional signals, capturing the intrinsic geometric structure of image, and also provides multi-resolution and directional image expansion[6]. It is derived using pyramidal directional filter banks which is a combination of laplacian pyramid and directional filter bank the laplacian pyramid has limitation in redundancy, about a factor of 4/3[7]. So we used a finest technique to decompose the image that is WBC transform. It is analogous to Contour let transform but the first stage laplacian pyramid filter bank is replaced with wavelet transform implemented through separable filter bank the second stage of WBC is a directional filter bank DFB provides angular decomposition implemented through non-separable filter banks.

The implementation of WBC [7]involves each level (M) in the wavelet transform, we obtain the traditional three high pass bands corresponding to the LH, HL, and HH bands.

We apply DFB with the same number of directions to each band in a given level (m). Starting from the desired maximum number of directions $N_D=2^L$ on the finest level of the wavelet transform M, we decrease the number of directions at every other dyadic scale when we proceed through the coarser levels (m< M). This way, we could achieve the anisotropy scaling law Which is the advantage of WBCT over the Contour let transform. Quad-tree decomposition of both low pass and high pass channels in wavelets and apply the DFB on each sub-band as shown in the above figure

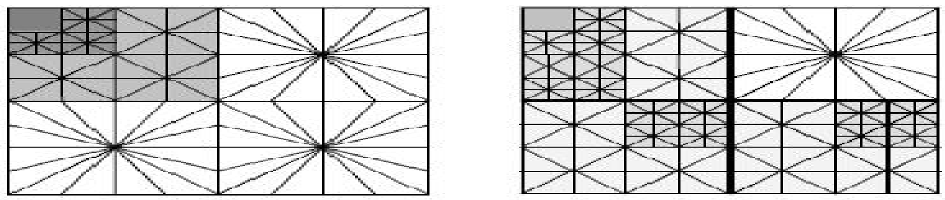

Fig 10: WBCT using 3 dyadic wavelet levels(N=8) and wavelet based contour let packets Following a similar procedure outlined in [3], for an l-level DFB we have 2^l directional sub bands with $G_K^{(l)}$,$0<K<2^L$ equivalent synthesis filters and the overall down sampling matrices of $S_K^{(l)}$

IV.SYSTEM ARCHITECTURE

The System Architecture involves following steps for processing the Bio-medical image

1. Load the Bio-Medical Image to the system and apply contour let transform for finding the edges of the image.
2. Next step is to encrypt the Bio-medical image using Hessen berg Matrix which is known as randomization of the image.
3. Apply Harr Wavelet for decomposition of the image and further quad-tree decomposition is done through passing the sub-band to contour let transform .
4. Finger print and Iris Enrollment is done to verify the authentication of valid user, which ensures the dual authentication scheme for the system.

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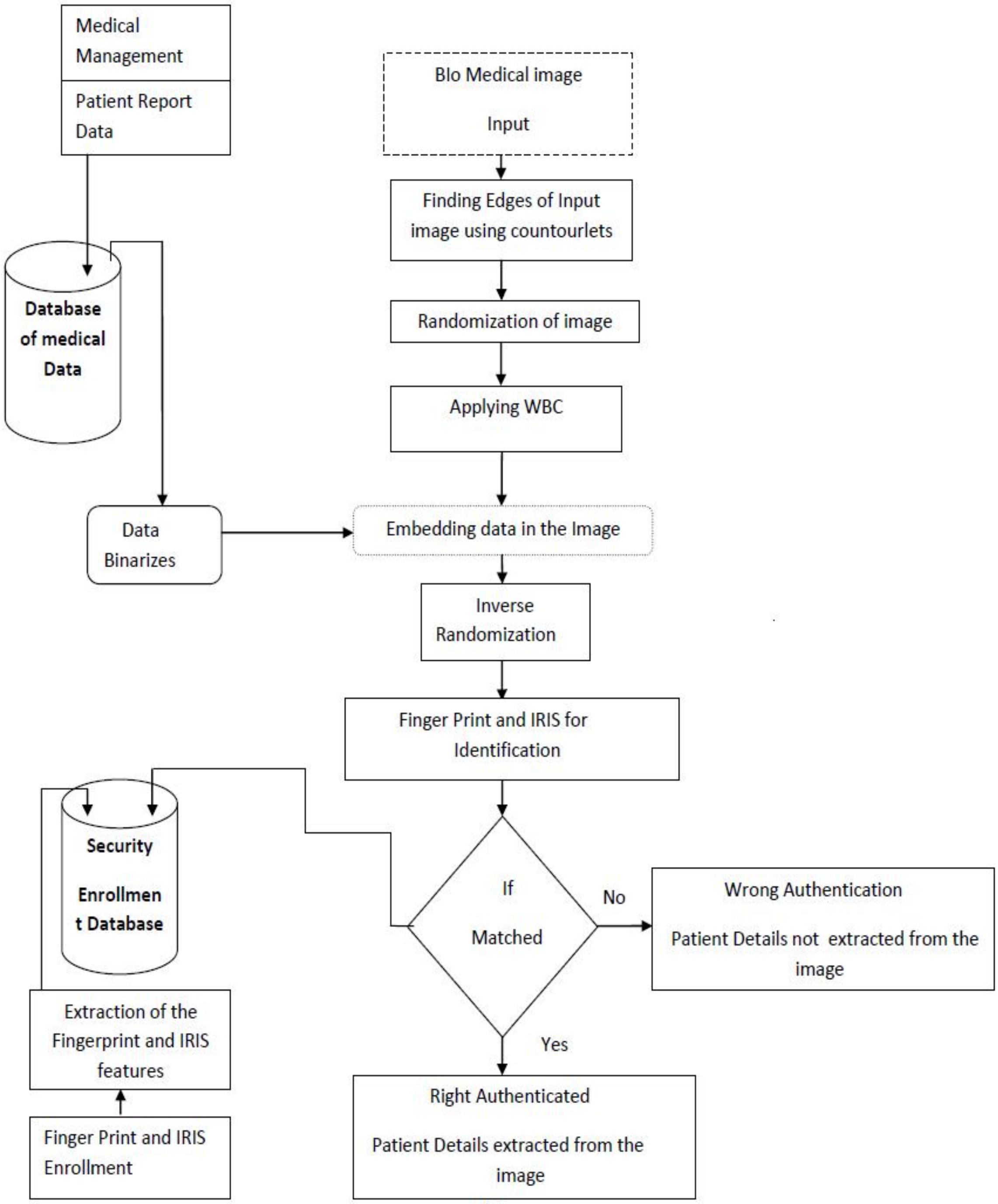
5. Embedding the patient data into the appropriate sub-band is done by watermarking scheme using wavelet based contour let transform.
6. Inverse randomization of image is done to ensure the decryption of the image.
7. Retrieval of the watermarked patient details from the bio-medical image is done by Authentication of both fingerprint and IRIS.
8. If authentication of user is mismatched then it displays unauthenticated user without extracting the watermarked patient data.



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V.RESULTS AND DISCUSSIONS

The Host Bio-medical image of T-Cross section area of a brain with a tumor is loaded to the system for displaying the input image and applying the contour let transform that identifies the edges of the cross sectional image. The schematic of input image and it's edges are as shown in below figures.

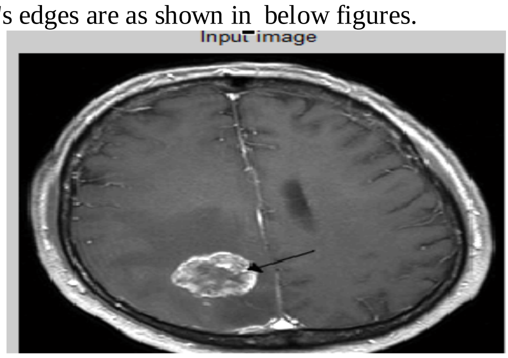

Fig 11: Input Image

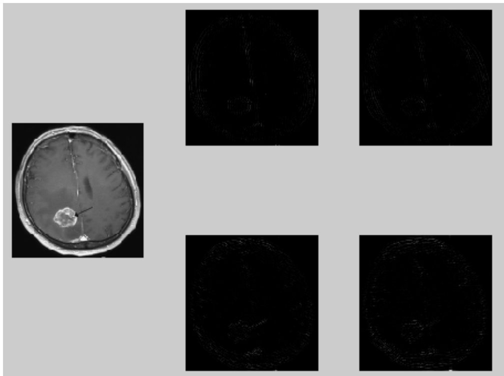

Fig 12: Edges of input image

The next step is to randomize the image for encryption purpose, which ensures the secure image transmission through the internet. For encryption we used Hessen berg matrix which is the cheapest matrix to compute [8].

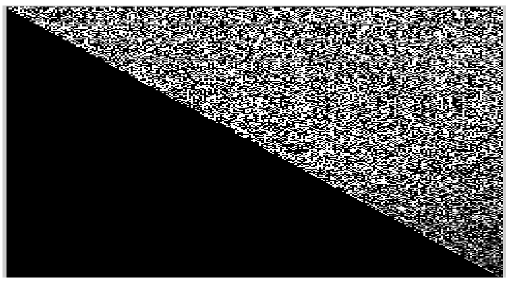

Fig 13: Randomization of Host Image

wavelet based contour let transform has been implemented by using Harr and Pyramidal Directional Filter Bank to select appropriate sub band for watermarking the patient details into the image. The WBC of given image are as shown figure 14.

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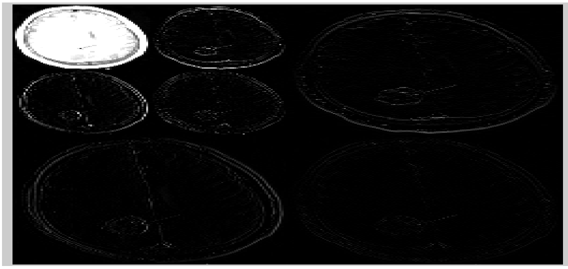


Fig 14:Wavelet Based Contour let

Next step is to enroll the biometric features of valid user using dual authentications, Finger print enrollment based on minutiae features and other is iris features enrolment based on Trapeze normalization. The fingerprint and it's minutiae points are shown in figure 8 .

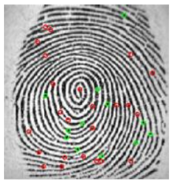
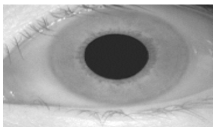
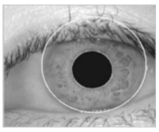


Fig 8: (a) Input Fingerprint (b) Minutiae Point on Fingerprint

In IRIS recognition the input image and it's segmented purple and IRIS part with normalized trapeze strip are as shown below figures





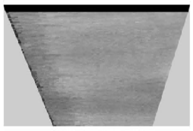


Fig 15: (a)Enrolled Input Eye (b)Hough Circle (c)Trapeze Strip

The next step is to watermark the patient details into the sub-band of the host image which undergone WBC. The watermarked image and details of the inserted patient details with its binary equivalent are depicted in figure 16.

```
Patient Number Is 123 Name:Venkatesh
Tumor  of 2.5X2.5 size Detected on T-Cross Section of Brain
000000000000000000000000001010000
000000000000000000000000001100001
000000000000000000000000001110100
000000000000000000000000001101001
000000000000000000000000001100101
000000000000000000000000001101110
```

Fig 16:Watermarked Patient Details

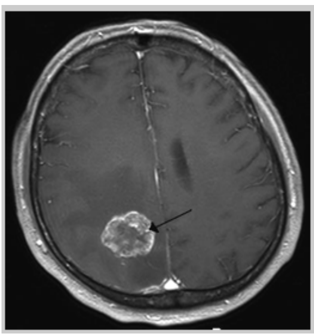


Fig 17: Water marked patient data

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Prior to Validate the received Medical Report it has to be decrypted using Inverse Randomization methodology by using public key through hessenberg matrix format[9].

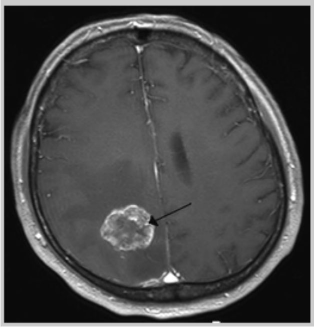


Fig 18: Inverse Randomized Image

If the verification is sucessful then the watermarked patient details are displayed with right authenctication message as shown in figure 19.

Right Authentication

Patient Number Is 123 Name:Venkatesh
Tumor of 2.5X2.5 size Detected on T-Cross Section of Brain

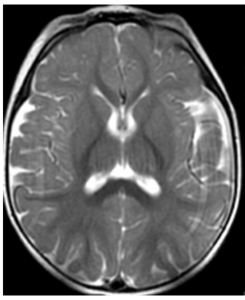
Fig 19: Extracted patient details

If either of finger print or Iris verifications is not successful then a message wrong authentication is displayed without extracting the patient details as shown in figure 20.

Wrong Authentication

Fig 20: Wrong Authenticate Message

The same process is recurred to the various input bio medical images which taken from the data set as shown in the figure 21, figure 22.



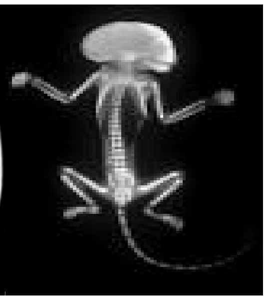


fig 21: Input Image 2 fig 22: Input Image3

The Efficiency of watermarking methodologies is tested for various input images and water marked images using PSNR MSE and Correlation Coefficient(CC) the various input images are as shown in the figure 11,figure 21 and figure 22 , and their results are depicted in Table I, Table II and Table III

TABEL I Comparison of Metrics Using Harr-Wavelet

FIGURE	Transform	PSNR	MSE	CC
Figure 11	wavelet Transform	34.8240	5.3987e+03	0.5196
Figure 21		31.4060	1.1998e+04	0.7146
Figure 22		36.3753	3.8012e+03	0.4962

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TABEL II Comparison of Metrics Using Contour let

FIGURE	Transform	PSNR	MSE	CC
Figure 11	Contour let Transform	34.873	5.4603e+03	0.9924
Figure 21		31.4050	1.2033e+04	0.9687
Figure 22		36.3970	3.8202e+03	0.9914

TABEL III Comparison of Metrics Using WBC

FIGURE	Transform	PSNR	MSE	CC
Figure 11	WBC Transform	52.2011	99.8876	1.0000
Figure 21		52.2712	98.2873	0.9998
Figure 22		52.1998	99.9183	1.0000

VI.CONCLUSIONS

Encryption, Verification and validation of Bio-medical image has been achieved through this proposed system. Redundancy and loss of Iris information in normalization has been avoided in dual authentication system using Trapezoidal normalization scheme. We also used WBC transform, one of the finest transform for water marking the patient details into the image. It ensures the visual information of the Bio-medical image is not altered. We also compared efficiency of the proposed decomposition methodology for watermarking, with existing methods (i.e.) using wavelet and contour let transforms for decompositions and observed significant improvement in all the metrics like PSNR, MSE and Correlation coefficient (CC) in proposed watermarking methodology using WBC. Further the proposed system can be extended to bio-medical videos like endoscopes, orthoscopes as a video water marking system.

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