ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

A NOVEL APPROACH TO MEDICAL IMAGE WATERMARKING FOR TAMPER DETECTION AND RECOVERY OF REGION OF INTEREST USING PREDICTIVE CODING AND HASHING

[1]K.CHAITANYA, [2]K.GANGADHARA RAO

[1]Assistant Professor, ANU College of Engineering and Technology, Dept of CSE, Acharya Nagarjuna University, Andhra Pradesh, India

[2]Professor, Dept of CSE, ANU College of Sciences, Acharya Nagarjuna University, Andhra Pradesh, India

E-mail: [1]anu.konda.chaitanya@gmail.com, [2]kancherla123@gmail.com

ABSTRACT

Telemedicine is an important application based on telecommunication and information technology to provide medical services to the remote patients with the advice of the healthcare professionals. The treatment is planned by analyzing the medical reports like CT scan, MRI scan, X-ray images etc. Hence, transmission of these images over internet needs integrity and security. Medical image watermarking has gained tremendous importance due to its catering needs in diagnosis, treatment planning, and to increase the security, confidentiality and integrity of the medical images. In medical image watermarking, the significant part of the medical image is treated as Region of Interest (ROI) that is important for diagnosis. Hence, it is very important to maintain integrity and transmit the ROI securely. In this paper, predictive coding and hashing technique is applied to ROI region in order to embed in Region of Non-Interest (RONI) to generate watermarked image. The proposed method, effectively extracts the ROI at the receiver side in spite of the tampering and noise added to it. The experimental results of the proposed method on various medical image databases proved to produce robust medical images to tampering. Compared with the existing techniques, the proposed method outperforms with the Peak Signal to Noise Ratio (PSNR) approximately 50dB.

Keywords: *Watermarking, Discrete Cosine Transform, Predictive Coding, Hashing, Peak Signal to Noise Ratio.*

1. INTRODUCTION

In the recent years most of the doctors are using telemedicine for the purpose of diagnosing the patients in far away locations. The medical images are transmitted between patients and doctors over the internet. There is a chance that medical images are modified by noise or unauthorized users. Moreover, it involves high cost to send the patient data & images separately, and the transmission time is also increased during the exchange of data [1]. It is very important to provide authentication and integrity to medical images by avoiding unauthorized access [2]. Hence medical image watermarking is an efficient tool to provide authenticity & integrity by embedding medical images and patient data.

Digital image watermarking gained importance in the recent years to provide security to the information for transmitting secretly over the internet [3]. Hiding the information into a digital signal like audio, video and image is called digital watermarking [4]. Digital image watermarking is divided into two groups namely visible watermarking and invisible watermarking. In visible watermarking, the embedded watermark is visible and in invisible watermarking, embedded information cannot be seen by the human eyes [5].

Based on the embedded information, watermarking techniques are classified as spatial and transform domain. In spatial domain, the data is embedded directly in to the Least Significant Bit plane of the cover image [6,7,8]. This technique is simple and the embedding capacity is also high. In the transform domain the watermark is embedding into the cover image after applying transformation techniques like Discrete Wavelet Transform and Discrete Cosine Transform [9,10]. The transform domain techniques produced better quality images when compared to spatial domain techniques.

Based on the type of application, watermarking is divided into three groups fragile, robust and hybrid methods. Fragile watermarking is mainly used for detecting tampers in the medical images done by the unauthorized persons during transmission of images [11]. Robust watermarking is mainly used for protecting the copyright information of images [12]. Hybrid watermarking is the combination of robust and fragile and mainly used for providing integrity and privacy control [13].

Digital image watermarking is also classified into two categories reversible and irreversible based on extraction of watermark. In reversible watermarking, the watermark and the cover image are recovered [14]. In irreversible watermarking, the watermark is extracted but not the cover image [15].

In order to protect and authenticate the medical data, medical image watermarking is used. In medical image watermarking, the medical image is divided into ROI and RONI [16, 17, 18]. ROI is the region that contains significant information for diagnosis and RONI is not useful for the diagnosis purpose. Hence, ROI is embedded into the RONI region in order to exchange over the internet.

Tan [18] introduced a dual-layer watermarking technique for tamper detection by dividing the image into 16X16 blocks and applying Cyclic Redundancy Check (CRC). Tampering is identified by comparing each CRC block with extracted ROI. The main drawback of the CRC technique is that a one bit change in CRC will lead to false detection of tampers.

Siau-ChuinLiew [16] implemented a region based watermarking for tamper detection and recovery by dividing ROI into 40X40 blocks and calculating CRC and calculates the hash value for each ROI block. On the other hand, each ROI block is saved as Joint Photographic Experts Group(JPEG) file with sequence number and then the coordinates of each ROI block are obtained. In this method the CRC, hash, JPEG file and the coordinates are embedded into the RONI region. In the decoding side, the ROI is divided into blocks, CRC is calculated and hashing is applied to each ROI block. If tampering occurs in image then the corresponding JPEG file is retrieved for recovering the ROI. As JPEG is lossy compression technique, ROI information is lost. In this method, false tamper detection happens with CRC technique.

Hui Liang Khor [19] was developed ROI-based tamper detection and recovery watermarking scheme (ROI-DR). At the encoding side predetermined ROI is used for all medical images and RONI is divided into different regions. ROI is compressed with JPEG compression and the compressed ROI is embedded into the LSB's of RONI. If tampering occurs at the decoding side then ROI is recovered from the RONI region which contains the compressed ROI. One of the disadvantages of the above technique is that it uses JPEG compression and hence, ROI information is lost. Another disadvantage is, predetermined ROI is used that can be easily identified by the unauthorized users. As ROI is varied with the medical images this method is not suitable for all types of medical images.

In order to overcome the disadvantage of lossy compression used in above mentioned techniques, predictive coding is used in the proposed method. In predictive coding the adjacent pixels difference is calculated and the bits required for the difference are only used in embedding instead of 8 bits. The predictive coding reduces the size of the bits to represent the ROI and hence, reduces the embedding information. In order to provide authenticity for ROI, SHA-256 hashing technique is used in the proposed method. This hashing technique is collision resistant as the hash value is not identified by the unauthorized user. The predictive coding values of ROI are embedded in LSB's of RONI and the hashing value of ROI is embedded using DCT in RONI. The proposed method is efficient in reducing the size of the ROI, producing high embedding capacity using LSB, more secure to unauthorized users using SHA-256 hashing technique. This method detects and effectively recovers the ROI even in case of tampering.

The proposed work was organized into the following sections. In Section 2, the preliminaries are discussed. In Section 3, the proposed methodology is presented. In Section 4, the

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

implementation and experimental results are discussed. The performance analysis is presented in Section 5 and Section 6 presents the conclusion & Future Scope.

2. PRELIMINARIES

2.1. Watermarking Process

The proposed medical image watermarking scheme contains two main processes, watermark embedding and authentication. In the encoding side, watermark is embedded into the medical image to generate the watermarked medical image. In the decoding side, to detect the occurrence of tampering watermark authentication process is used. Figure 1 illustrated the basic skeleton of the watermarking technique.

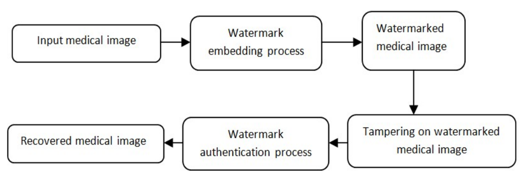

Figure 1: Basic Skeleton Of The Watermarking Technique

2.2. ROI selection:

The medical image is composed of two regions ROI and RONI [16, 17, 18]. As the ROI is the region with important information, the selection of ROI region is done by the physician. The selected ROI coordinates are used to divide the RONI into 4 parts LEFT_RONI, RIGHT_RONI, TOP_RONI and BOTTOM_RONI as shown in Figure 2. In order to extract the ROI coordinates in the decoding process, these coordinates are embedded from the next position of RONI having maximum adjacent pixel difference by moving into the right direction from the centre of the medical image. Hence, it is difficult to identify the ROI region coordinates by the unauthorized users.

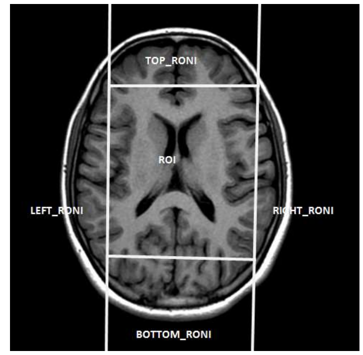

Figure 2. ROI And RONI Regions Of Medical Image

In the proposed paper different types of medical images are taken shown in Figure 3. Table 1 shows the ROI sizes of the different medical images. Medical images 1, 2, 3 and 4 are the DICOM formatted images and are converted into PNG format as they are lossless format [20, 21] and medical images 5 and 6 are taken from MedPix database which are in PNG format [22].

Table 1: ROI Sizes Of The Different Medical Images

Medical Images	Image Size	ROI Size
Medical Image 1	737 X 743	201 X 201
Medical Image 2	512 X 512	131 X 121
Medical Image 3	512 X 512	141 X 161
Medical Image 4	512 X 512	151 X 151
Medical Image 5	505 X 512	201 X 101
Medical Image 6	585 X 512	201 X 101

2.3. Predictive Coding

ROI is embedded into RONI using spatial and transform domain techniques. The spatial domain techniques [6, 7, 8] produce high embedding capacity. In these techniques the ROI pixel values are converted into binary and are embedded into LSB's of RONI. Instead of embedding the pixel values of ROI directly, predictive coding is applied to reduce the embedding capacity. The authenticity of ROI is obtained by embedding the hash value of ROI in RONI using transform domain DCT technique [9, 10].

The predictive coding works by converting ROI region into ROI vector by traversing in the specified path shown in Figure 4. Traversing in the specified path gives the less difference of the adjacent pixels. In extreme sides of ROI the predictive coding produces value with less difference as they are adjacent.

Journal of Theoretical and Applied Information Technology
15th April 2018. Vol.96. No 7

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

12	15	18	13	16	10
4	8	12	16	14	11
8	16	14	19	13	12
6	8	10	12	16	14
7	5	3	6	9	12
10	12	14	16	12	10

Figure 4: Traversing ROI Region

Predictive coding is a lossless compression technique. It compresses the ROI vector by finding the adjacent pixel difference to get the predictive error [23]. The predictive error is the difference between the current pixel value and its predecessor pixel value. Each pixel except the first value in the ROI vector contains the predictive error rather than its original value after applying predictive coding and the value is less compared to the original value. The first value in the ROI vector send as it is which is used for decoding purpose. The predictive coding encoder and decoder calculations are given in Equations 1, 2 and 3.

Predictive coding encoder :

$$\hat{f}_n = f_{n-1} \quad (1)$$

$$e = f_n - \hat{f}_n \quad (2)$$

Predictive coding decoder :

$$f_n = e + \hat{f}_n \quad (3)$$

Where f_n is the current value in the ROI vector, $\hat{f}_n$ is the previous value of f_n in the ROI vector and e is predictive error, the difference between current pixel and previous pixel in the ROI vector.

Figure 5 shows the ROI vector and their predictive errors of the ROI vector shown in Figure 4. The predictive errors are converted into binary form and placed in STREAM vector. While converting the predictive errors into binary form one extra bit is used for representing positive and negative numbers. The positive number is represented with zero and negative number is represented with one. The number of bits needed to each predictive error is placed in SIZE vector of size 3 bits if the value of any one of the predictive error is less than 127 and 4 bits if the value of any one of the predictive error is greater than or equal to 128 shown in Figure 6.

ROI vector:

12, 15, 18, 13, 16, 10, 11, 14, 16, 12, 8, 4, 8, 16, 14, 19, 13, 12, 14, 16, 12, 10, 8, 6, 7, 5, 3, 6, 9, 12, 10, 12, 16, 14, 12, 10

Total number of bits needed for ROI vector = 36 pixels X 8 bits= 288 bits

Predictive errors:

12,0, 3, 3, -5, 3, -6, 1, 3, 2, -4, -4, -4, 4, 8, -2, 5, -6, -1, 2, 2, -4, -4, -2, -2, -2, 1, -2, -2, 3, 3, 3, -2, 2, 4, -2, -2, -2

Number of bits needed for SIZE vector=111+3=114 bits (extra 3 bits for representing first value 12)

Number of bits needed for STREAM vector=119+5=124 bits (extra 5 bits for representing first value 12)

Total number of bits needed for SIZE and STREAM vectors=114+124=238 bits

Hash value of ROI:

448649b2d75a44bd5da130cf452daae12cd8b63a94878ec9ba6eeed687aad8a3

Extracting SIZE and STREAM vectors at decoding side from LEFT RONI:

SIZE vector:

1010100110111000111000100110111001001001001000111001000100110111001000110110110100110110110110110110111000110110 11

STREAM vector extraction based on SIZE vector:

011000001101111010111110010110101100110011000100100011001011110110100101100110011011011001110110011011011110010010011011 0110

Predictive errors extraction based on STREAM vector:

12,0, 3, 3, -5, 3, -6, 1, 3, 2, -4, -4, -4, 4, 8, -2, 5, -6, -1, 2, 2, -4, -4, -2, -2, -2, 1, -2, -2, 3, 3, 3, -2, 2, 4, -2, -2, -2

ROI vector after reverse predictive coding:

12, 15, 18, 13, 16, 10, 11, 14, 16, 12, 8, 4, 8, 16, 14, 19, 13, 12, 14, 16, 12, 10, 8, 6, 7, 5, 3, 6, 9, 12, 10, 12, 16, 14, 12, 10

Figure 5: ROI Vector, Corresponding Predictive Errors And Hash Value Of ROI

STREAM vector

Predictive error	Binary form
0	00
3	011
3	011
-5	1101
3	011
-6	1110
1	01
3	011
2	010
-4	1100
-4	1100
-4	1100
4	0100
8	1000
-2	110
5	0101
-6	1110
-1	11
2	010
2	010
-4	1100
-4	1100
-2	110
-2	110
-2	110
1	01
-2	110
-2	110
3	011
3	011
3	011
-2	110
2	010
4	0100
-2	110
-2	110
-2	110
Total	119 bits

SIZE vector

Bits needed to each predictive error	Binary form
2	010
3	011
3	011
4	100
3	011
4	100
2	010
3	011
3	011
4	100
4	100
4	100
4	100
4	100
3	011
4	100
4	100
2	010
3	011
3	011
4	100
4	100
3	011
3	011
3	011
2	010
3	011
3	011
3	011
3	011
3	011
3	011
3	011
4	100
3	011
3	011
3	011
Total	111 bits

Figure 6: STREAM And SIZE Vectors

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

The SIZE and STREAM vectors are embedded into the two LSB's of each pixel in the LEFT_RONI. The predictive coding has advantage of representing the ROI with less number of bits when compared to the actual number of bits of ROI and hence reduces the number of bits of ROI embedding in LEFT_RONI. Table 2 shows the total number of bits of ROI before and after predictive coding. The graph constructed by the values of Table 2 is shown in Figure 7.

Table 2: Number Of ROI Bits Before And After Predictive Coding

Medical Images	Total pixels in ROI	Actual bits of ROI	ROI bits after predictive coding
Medical Image 1	40401	323208	246049
Medical Image 2	15851	126808	99125
Medical Image 3	22701	181608	151803
Medical Image 4	22801	182408	148548
Medical Image 5	20301	162408	121925
Medical Image 6	20301	162408	127133

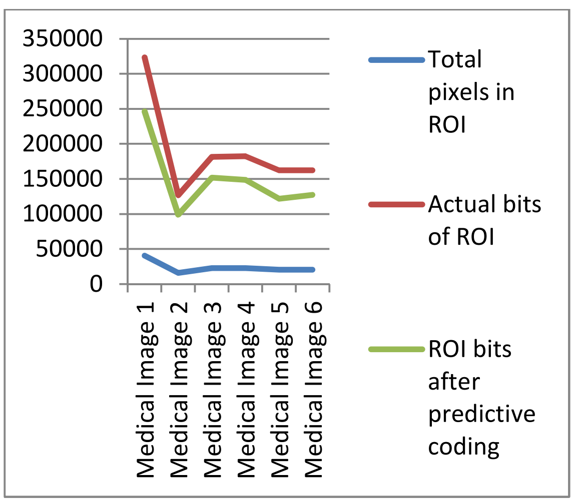

Figure 7: ROI Bits Before And After Predictive Coding Comparison Graph

At the decoding side extract the binary data from the 2 LSB's of LEFT_RONI. Extract SIZE vector from the binary stream with the size of ROI. Based on the value in the SIZE vector extract that many number of bits from the binary stream followed by the SIZE vector to get the STREAM vector shown in Figure 5.

2.4. Hashing

The authenticity of ROI is very important while transmitting the medical image over the internet. SHA-256 algorithm is used in the proposed method to encrypt the hash value of ROI into RONI. SHA-256 stands for Secure Hash Algorithm and it is one of the cryptographic hash functions. SHA-256 generates unique fixed size hash value with digest length of 256 bit [24]. It is a one-way hash function. This algorithm is suitable for authentication, integrity and digital signatures, etc. The integrity and authentication of the data can be determined by comparing the computed hash value with the expected hash value. One of the main advantages of SHA-256 is its collision resistance and stronger when compared to SHA-1 and SHA-2. SHA-2 algorithms are available as SHA-256 and SHA-512. SHA-512 uses 512 bits to generate hash function and is more complex compared to SHA-256. Hence, in the proposed method SHA-256 is used for better computation. In the proposed method SHA-256 is used for generating hash value for ROI and LEFT_RONI in order to verify tampering. The example hash message generated by SHA-256 is given in Figure 5.

2.5. Discrete Cosine Transform and Mid Frequency Coefficients

The hash message generated by SHA-256 is embedded into RONI using block-based Discrete Cosine Transform (DCT). The DCT is the most popularly used technique in digital image watermarking. DCT transforms the image from spatial domain to frequency domain and also separates the image into sub-bands of differing importance. In the proposed method, image is divided into number of non-overlapping blocks and for each block DCT is applied. The proposed method divides the TOP_RONI, RIGHT_RONI and BOTTOM_RONI into 8 X 8 blocks. The DCT of each block transforms the signal into low-frequency, mid-frequency and high-frequency sub-bands [25] using Equation 4. The generated sub-bands of the DCT are shown in Figure 8.

$$F(u,v) = \left(\frac{2}{N}\right)^{\frac{1}{2}}\left(\frac{2}{M}\right)^{\frac{1}{2}}\sum_{i=0}^{N-1}\sum_{j=0}^{M-1} A(i).A(j).\cos\left[\frac{\pi.u}{2.N}(2i+1)\right]\cos\left[\frac{\pi.v}{2.M}(2j+1)\right].f(i,j) \quad (4)$$

low	low	low	mid	mid	mid	mid	high
low	low	mid	mid	mid	mid	high	high
low	mid	mid	mid	mid	high	high	high
mid	mid	mid	mid	high	high	high	high
mid	mid	mid	high	high	high	high	high
mid	mid	high	high	high	high	high	high
mid	high	high	high	high	high	high	high
high	high	high	high	high	high	high	high

Figure 8: Low, Mid And High Frequency Coefficients Of The DCT Block

The mid-frequency coefficients of each DCT block are used for embedding the generated hash values of ROI and LEFT_RONI. Here mid-frequency coefficients are used as most of the visual information is stored in low-frequency sub-bands and high-frequency sub-band information is removed if any attacks occur. The generated hash value of ROI is embedded in DCT transformed mid-frequency coefficients of TOP_RONI and the generated hash value of LEFT_RONI is embedded in DCT transformed mid-frequency coefficients of RIGHT_RONI, BOTTOM_RONI. This method is used to embed the hash value generated by SHA-256 in order to authenticate the ROI by the receiver.

3. PROPOSED WORK

The detailed steps used in the embedding, extraction and authentication procedures of medical images using the proposed method are listed below:

3.1. Watermark Embedding Procedure

The ROI is embedded into the RONI to generate watermarked medical image. The steps for the embedding process are listed below. Figure 9 shows the watermark embedding process.

1. The medical image is divided into ROI and RONI blocks by selecting the ROI region by the physician.

2. The selected coordinates of ROI are embedded at the position with maximum adjacent pixel difference from the centre of the image to the right.

3. The RONI block is divided into 4 regions LEFT_RONI, RIGHT_RONI, TOP_RONI and BOTTOM_RONI.

4. Calculate SHA-256 for the ROI block to obtain 64 byte hexadecimal hash value and convert each hexadecimal value into binary value.

5. TOP_RONI is divided into blocks of size 8 X 8 and for each block DCT is applied using Eq.4. Embed binary value of each hexadecimal value into the mid-frequency coefficients of each DCT block and apply inverse DCT.

6. Traverse the ROI block in the specified path as shown in Fig.3 and generate an ROI vector.

7. Apply predictive coding to the ROI vector to generate predictive error vector as discussed in section 2.3. The predictive errors are having fewer values compared to the ROI vector.

8. Create two vectors, STREAM vector and SIZE vector. The STREAM vector stores the binary value of each predictive error. The SIZE vector stores the number of bits required for each predictive error represented in binary form.

9. Combine the SIZE vector and the STREAM vector to get the BINARY vector. Embed each 2 bits of BINARY vector into two LSB's of each pixel of LEFT_RONI.

10. Calculate SHA-256 to the LEFT_RONI to generate 64 byte hexadecimal hash value and convert each hexadecimal value into binary value.

11. RIGHT_RONI is divided into blocks of size 8 X 8 and DCT is applied for each block. Embed binary value of each LEFT_RONI hexadecimal value into the mid-frequency coefficients of each DCT block and apply inverse DCT.

12. Repeat step 11 for BOTTOM_RONI and also embed the patient information.

13. Combine the ROI and the modified LEFT_RONI, RIGHT_RONI, TOP_RONI and BOTTOM_RONI to obtain the watermarked medical image.

3.2. Watermark Authentication and Extraction Procedure

The ROI is extracted from the watermarked medical image and authenticated for unauthorized users and tampering. The steps for the extraction and authentication process are listed below. Figure 10 shows the watermark authentication and extraction procedure.

1. The first step is to extract the position of the ROI coordinates from the watermarked medical image. To do so, retrieve the position stored towards the right from the centre of the image having maximum adjacent pixel difference.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

2. Extract two LSB's from the pixel with maximum adjacent pixel difference position.

3. Divide the watermarked medical image into ROI and RONI blocks.

4. Divide the RONI block into 4 regions LEFT_RONI, RIGHT_RONI, TOP_RONI and BOTTOM_RONI.

5. Calculate SHA-256 for the ROI region to get 64 byte hexadecimal hash value for authentication.

6. TOP_RONI is divided into blocks of size 8X8 and for each block DCT is applied. Extract the 64 byte hexadecimal hash value from the mid-frequency coefficients of each DCT block of TOP_RONI.

7. Compare ROI hash value with the extracted hash value of TOP_RONI. If these two hash values are same then no tampering is occurred in ROI region else there is a tampering occurred either in ROI region or in TOP_RONI region.

8. In case of tampering in ROI or in TOP_RONI then extract the binary stream from the 2 LSB's of LEFT_RONI. Extract SIZE vector from the binary stream based on the ROI size. Extract STREAM vector based on the value in the SIZE vector. Apply inverse predictive coding to the STREAM vector to obtain predictive vector.

9. Traverse the ROI block in the specified path to obtain the ROI vector as shown in figure.3. Compare ROI vector with the predictive vector. If these two vectors are same then there is no tampering in ROI region else tampering is occurred in either ROI region or LEFT_RONI.

10. In case of tampering in either ROI region or LEFT_RONI, calculate SHA-256 for LEFT_RONI. Extract the 64 byte hexadecimal hash value from the mid-frequency coefficients of each DCT block of RIGHT_RONI. Compare hash values of LEFT_RONI and RIGHT_RONI.

11. If the two hash values are same then tampering is done in ROI region. Hence, ROI is recovered with the predictive vector in the specified path as shown in Figure 3.

12. If the two hash values are not same then extract the 64 byte hexadecimal hash value from the mid-frequency coefficients of each DCT block of BOTTOM_RONI. Compare hash values of LEFT_RONI and BOTTOM_RONI.

13. If these two values are same tampering done at ROI region then ROI is recovered with the predictive vector. If the two hash values are not same then tampering is done in LEFT_RONI or BOTTOM_RONI.

The proposed method can recover the ROI if there is tampering in ROI, TOP_RONI, RIGHT_RONI and BOTTOM_RONI. The method fails only if the tampering is done at LEFT_RONI and ROI regions simultaneously as it cannot recover the ROI.

4. IMPLEMENTATION AND EXPERIMENTAL RESULTS

The proposed method is implemented on the medical images with 8 bits per pixel collected from DICOM [20, 21] and Medpix®[22]. The proposed method is executed on Matlab 2013a with Intel core2 duo 2.10GHz processor of 4 GB RAM. The proposed method is evaluated subjectively and objectively and proved to be efficient when compared to existing methods.

Different types of medical images with different sizes and different ROI sizes are taken for the embedding process are shown in Figure 3. Figure 11 shows the results of medical images 1 to 6 after embedding ROI in RONI region.(a)(c)(e)(g)(i)(k) in Figure 11 shows the original medical images.(b)(d)(f)(h)(j)(l) in Figure 11 shows the watermarked medical images.

After performing the watermark embedding procedure watermarked medical image is obtained. Transmit this watermarked medical image to the destination. While transmitting the watermarked medical image to the destination, tampering may occur in regions of ROI, TOP_RONI, LEFT_RONI, RIGHT_RONI, BOTTOM_RONI and also the combinations of different regions. The following cases are shown if tampering is done at different regions then how the ROI is recovered using authentication process.

Case 1: Recovery of ROI when tampering is done in TOP_RONI with invert colour tampering shown in Figure 11.

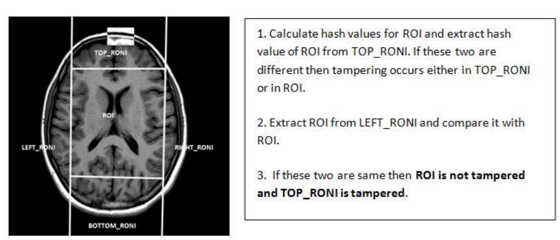

Figure 11: Recovery Of ROI When Tampering Is Done In TOP_RONI

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Case 2: Recovery of ROI when tampering done in LEFT_RONI with invert colour tampering shown in Figure 12.

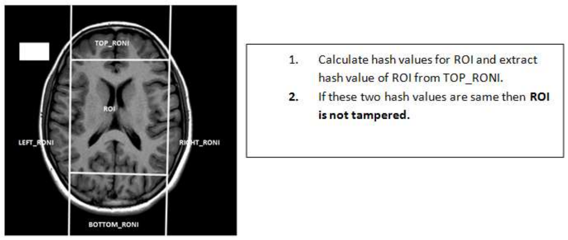

Figure 12: Recovery Of ROI When Tampering Is Done In LEFT_RONI

Case 3: Recovery of ROI when tampering done in RIGHT_RONI with vertical flip tampering shown in Figure 13.

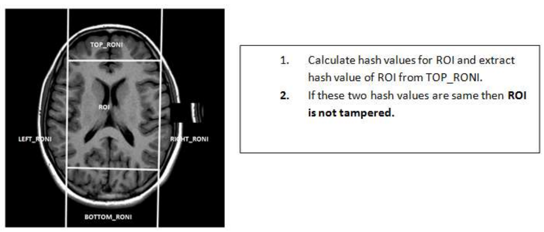

Figure 13: Recovery Of ROI When Tampering Is Done In RIGHT_RONI

Case 4: Recovery of ROI when tampering done in BOTTOM_RONI shown in Figure 14.

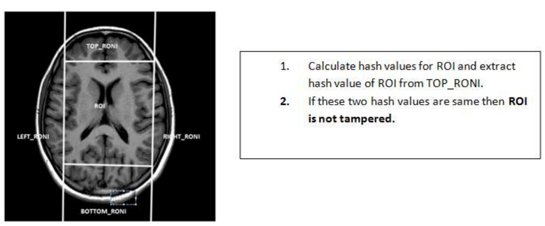

Figure 14: Recovery Of ROI When Tampering Is Done In BOTTOM_RONI

Case 5: Recovery of ROI when tampering done in ROI with cropping shown in Figure 15.

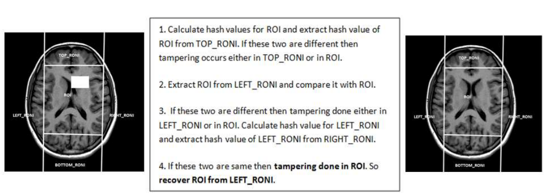

Figure 15: Recovery Of ROI When Tampering Is Done In ROI

Case 6: Recovery of ROI when tampering done in TOP_RONI and ROI simultaneously using cropping shown in Figure16.

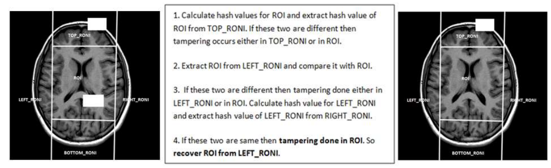

Figure 16: Recovery Of ROI When Tampering Is Done In TOP_RONI And ROI

Case 7: Recovery of ROI is not possible when tampering done in ROI and LEFT_RONI simultaneously shown in Figure 17.

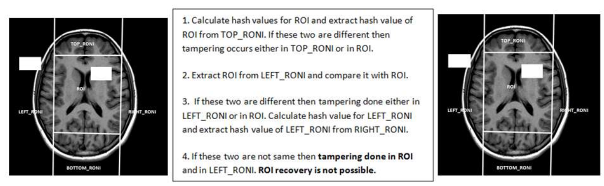

Figure 17: Recovery Of ROI When Tampering Is Done In LEFT_RONI And ROI

Case 8: Recovery of ROI when tampering done in ROI and RIGHT_RONI simultaneously shown in Figure 18.

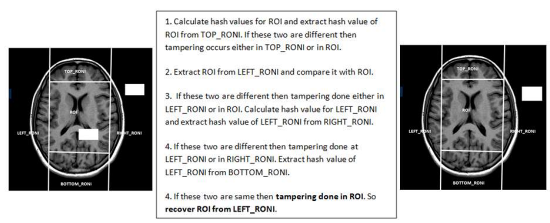

Figure 18: Recovery Of ROI When Tampering Is Done In RIGHT_RONI And ROI

Case 9: Recovery of ROI when tampering done in ROI and BOTTOM_RONI simultaneously shown in Figure 19.

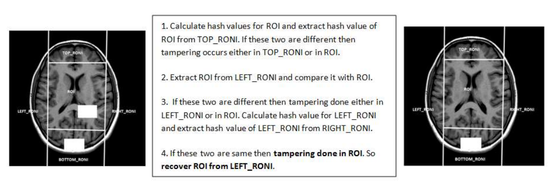

Figure 19: Recovery Of ROI When Tampering Is Done In BOTTOM_RONI And ROI

Figure 20 shows the embedding and the extraction process of ROI in case of tampering in ROI and RONI simultaneously. Different types of tampering like blurring, cropping, rotating etc are used. In Figure 20 column 1 shows the original medical images, column 2 shows the watermarked medical images, columns 3 & 5 shows the tampered medical images both in ROI and RONI and columns 4 & 6 shows the recovered medical images.

5. PERFORMANCE ANALYSIS

The performance of the proposed method is evaluated by the Mean Square Error (MSE) and Peak Signal to Noise Ratio (PSNR).

5.1. Mean Square Error

MSE is the average of the squares of the errors between two images. It calculates the distortion between the original medical image and watermarked medical image on the basis of their pixel differences [26].

Mean Square Error is an error metric which represents the cumulative squared error between the original medical image and watermarked medical image. As the value of MSE decreases, the error decreases. The Equation 5 for MSE is given below:

$$MSE = \frac{\sum_{r,c}[M(r,c)-WM(r,c)]^2}{r*c} \quad (5)$$

Where r & c are the number of rows and columns of the medical image. M is the original medical image and WM is the watermarked medical image.

5.2. Peak Signal to Noise Ratio

Peak Signal to Noise Ratio (PSNR) is an error metric which measures the quality of the original medical image and watermarked medical image [27]. It is a measure of peak error represented in decibels. As the PSNR increases the quality of the watermarked medical image increases. The Equation 6 for PSNR is given below:

$$PSNR = 10 \quad \log_{10}\left(\frac{R^2}{MSE}\right) \quad (6)$$

Where R is the maximum fluctuations in the input medical image.

The Table 3 shows the PSNR values of the different medical images and these results are compared with the existing methods. Figure 21 shows the comparison of PSNR of the proposed method with the existing methods TALLOR [16] & ROI-DR [19]. The proposed method outperforms when compared to the existing methods with an increased PSNR value.

Table 3: PSNR Values Of The Different Medical Images

Images	TALLOR [16]	ROI-DR [19]	Proposed method
Medical Image 1	48.5933	49.4824	51.548
Medical Image 2	48.4652	49.5853	50.5948
Medical Image 3	48.8643	49.0243	50.1817
Medical Image 4	48.994	49.6372	50.4823
Medical Image 5	48.6342	48.9996	50.0195
Medical Image 6	48.1635	48.9034	50.1061

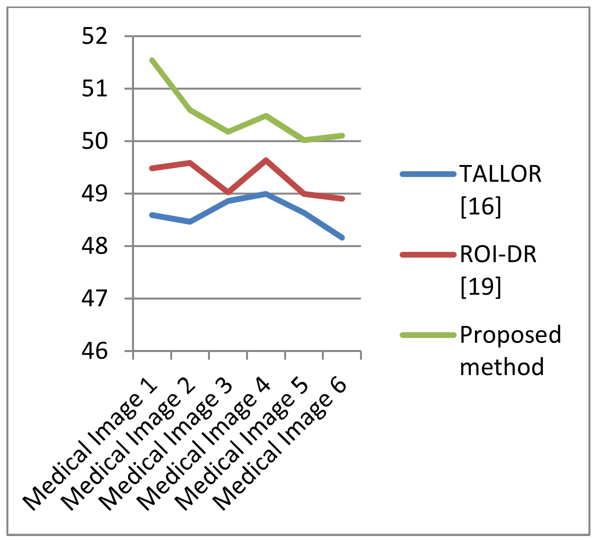

Figure 21: Comparing PSNR Of The Proposed Method With The Existing Methods

6. CONCLUSION & FUTURE WORK

The tamper detection and recovery of medical images using predictive coding and SHA-256 is efficient when compared to the existing techniques as it requires less number of bits to represent the predictive errors of ROI instead of embedding the ROI directly. The proposed predictive coding, a lossless compression technique reduces the number of bits in ROI region, increases the embedding capacity. The performance measures like Mean Square Error, Peak Signal to Noise Ratio are evaluated for the proposed method. The

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

proposed method showed improved PSNR value and increased MSE when compared to the existing method. The SHA-256 is useful for authentication purpose to check whether the ROI is tampered or not. The proposed method is efficient in extracting the ROI even in case of tampering at ROI, TOP_RONI, RIGHT_RONI and BOTTOM_RONI. The proposed method produces accurate results in terms of embedding capacity and performance measures. In future work, the techniques need to improve the embedding capacity, recover the ROI if tampering occurs both in ROI, RONI and must be an improvement in Peak Signal to Noise Ratio.

REFERENCES:

[1]. Pan, Wei, et al. "Medical image integrity control combining digital signature and lossless watermarking." *Data privacy management and autonomous spontaneous security*. Springer Berlin Heidelberg, 2010, pp.153-162.

[2]. Coatrieux, Gouenou, et al. "Mixed reversible and RONI watermarking for medical image reliability protection." *Engineering in Medicine and Biology Society, 2007.EMBS 2007.29th Annual International Conference of the IEEE*.IEEE, 2007.

[3]. Cox, Ingemar J., and Matt L. Miller. "Review of watermarking and the importance of perceptual modeling." *Electronic Imaging'97*. International Society for Optics and Photonics, 1997.

[4]. CoxIJ, etal, "Secure spread spectrum watermarking of multimedia". Image Processing, IEEE Transactions on 6.12(1997), pp: 1673-1687.

[5]. Dhiman, Swati, and Onkar Singh. "Analysis of Visible and Invisible Image Watermarking â [euro]" A Review." *International Journal of Computer Applications* 147.3, 2016.

[6]. Feyzi, A. K. A. R., YıldırayYalman, and HüseyinSelçukVarol. "Data hiding in digital images using a partial optimization technique based on the classical LSB method." *Turkish Journal of Electrical Engineering and Computer Science* 21.Sup. 1 2013, pp: 2037-2047.

[7]. Nikolaidis, Nikos, and Ioannis Pitas. "Digital image watermarking: an overview." *Multimedia Computing and Systems, 1999.IEEE International Conference on*.Vol. 1. IEEE, 1999.

[8]. Wenyin, Zhang, and Frank Y. Shih. "Semi-fragile spatial watermarking based on local binary pattern operators." *Optics Communications* 284.16 (2011): 3904-3912.

[9]. Zhang, Q., Y. Li, and X. Wei. "An improved robust and adaptive watermarking algorithm based on DCT." *Journal of applied research and technology* 10.3 2012, pp: 405-415.

[10]. Das, Chinmayee, et al. "A novel blind robust image watermarking in DCT domain using inter-block coefficient correlation." *AEU-International Journal of Electronics and Communications* 68.3 (2014): 244-253.

[11]. Al-Haj A, Amer A: Secured telemedicine using region-based watermarking with tamper localization. J Digit Imaging 8(3):737– 750, 2014

[12]. Chiang, Kuo-Hwa, et al. "Tamper detection and restoring system for medical images using wavelet-based reversible data embedding." *Journal of Digital Imaging* 21.1 (2008): 77-90.

[13] Mousavi, Seyed Mojtaba, Alireza Naghsh, and S. A. R. Abu-Bakar. "Watermarking techniques used in medical images: a survey." *Journal of digital imaging* 27.6 (2014): 714-729.

[14]. Li, C-T. "Digital fragile watermarking scheme for authentication of JPEG images." *IEE proceedings-vision, image and signal processing* 151.6 (2004): 460-466.

[15]. Guo, Xiaotao, and Tian-geZhuang. "Lossless watermarking for verifying the integrity of medical images with tamper localization." *Journal of digital imaging* 22.6 (2009): 620.

[16]. Liew, Siau-Chuin, Siau-Way Liew, and JasniMohdZain. "Tamper localization and lossless recovery watermarking scheme with ROI segmentation and multilevel authentication." *Journal of digital imaging* 26.2 (2013): 316-325.

[17]. Thakkar, Falgun N., and Vinay Kumar Srivastava. "A blind medical image watermarking: DWT-SVD based robust and secure approach for telemedicine applications." *Multimedia Tools and Applications* 76.3 (2017): 3669-3697.

[18]. Tan, Chun Kiat, et al. "Security protection of DICOM medical images using dual-layer reversible watermarking with tamper detection capability." *Journal of Digital Imaging* 24.3 (2011): 528-540.

[19]. Khor, Hui Liang, Siau-ChuinLiew, and JasniMohdZain. "Region of Interest-Based Tamper Detection and Lossless Recovery Watermarking Scheme (ROI-DR) on Ultrasound Medical Images." *Journal of Digital Imaging* (2017): 1-22.

[20]. Varma, Dandu Ravi. "Managing DICOM images: Tips and tricks for the radiologist." *The Indian journal of radiology & imaging* 22.1 (2012): 4.

[21]. An introduction to the DICOM single-file format. Available from: http://www.cabiatl.com/mricro/dicom/index.html.

[22]. The National Library of Medicine presents MedPix® Available from : https://medpix.nlm.nih.gov/home

[23]. Fundamentals of Multimedia Ze-Nian Li, Mark S Drew, 2004, Pearson

[24]. Das, Sudeb, and Malay Kumar Kundu. "Effective management of medical information through ROI-lossless fragile image watermarking technique." *Computer methods and programs in biomedicine* 111.3, 2013, pp: 662-675.

[25]. Roy, Soumitra and Arup Kumar Pal. "A blind DCT based color watermarking algorithm for embedding multiple watermarks." *AEU-International Journal of Electronics and Communications* 72, 2017, pp: 149-161.

[26]. Wang, Zhou, et al. "Image quality assessment: from error visibility to structural similarity." *IEEE transactions on image processing*13.4, 2004, pp: 600-612.

[27]. Hore Alain, Djemel Ziou, "Image quality metrics: PSNR vs. SSIM." *Pattern recognition (icpr), 2010 20th international conference on* IEEE, 2010, pp. 2366-2369.

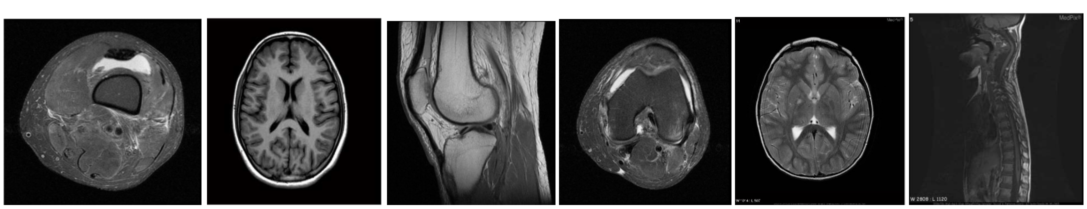

Figure 3: Medical Images 1 To 6

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

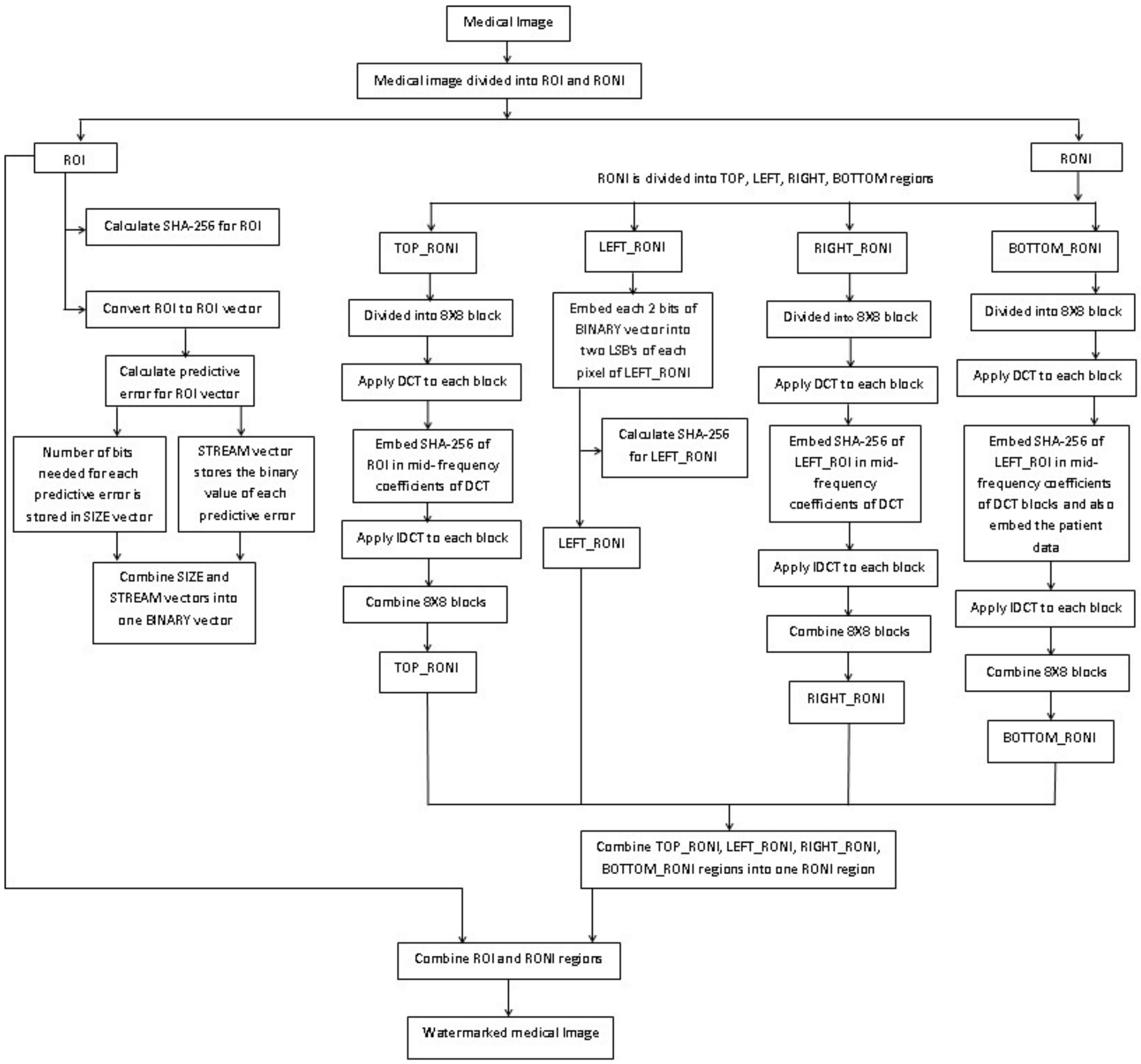

Figure 9: Watermark Embedding Process

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

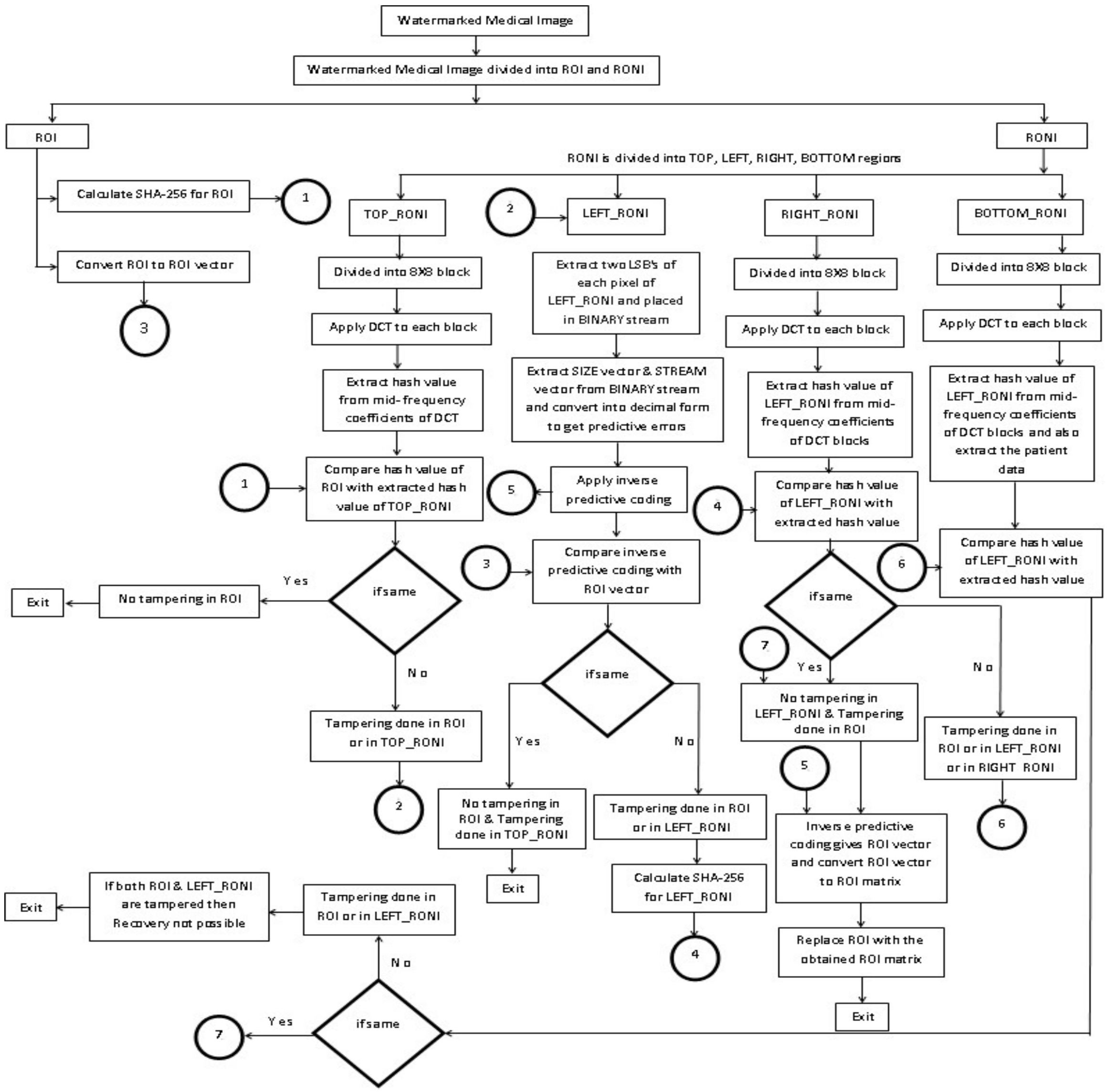

Figure 10: Watermark Authentication And Eextraction Process

Journal of Theoretical and Applied Information Technology
15th April 2018. Vol.96. No 7

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

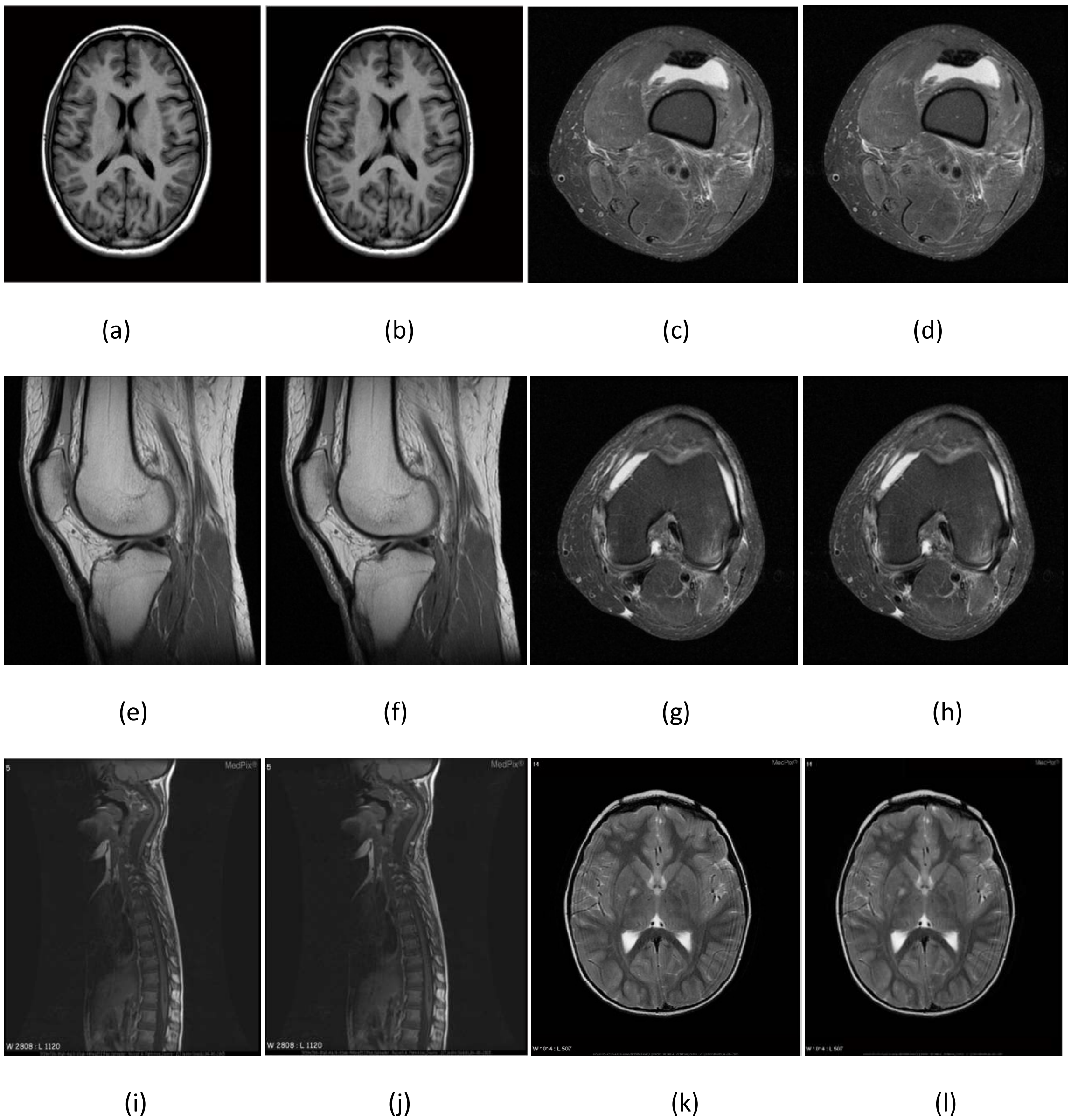

Figure 11: (a)(c)(e)(g)(i)(k) Shows Original Medical Images and (b)(d)(f)(h)(j)(l) Shows Watermarked Medical Images

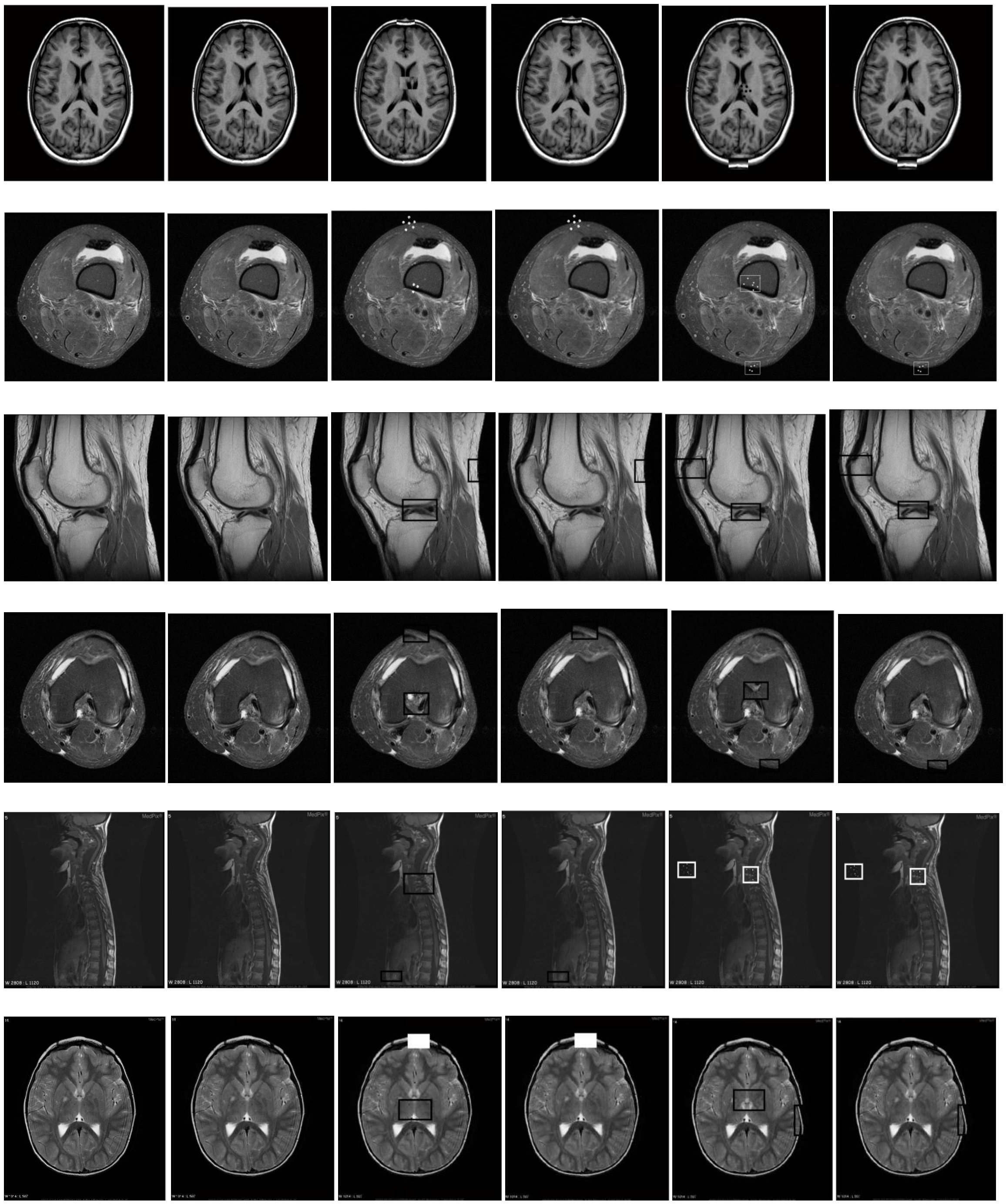

Figure 20: The Embedding And The Extraction Process Of ROI In Case Of Tampering