Medical Image Compression Based on Transform Technique

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MEDICAL IMAGE COMPRESSION BASED ON TRANSFORM TECHNIQUE

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ABSTRACT:

In medical field image compression is an important thing to store their information efficiently. But the size of the compression image is missed at the time of compression and decompression. To alleviate this problem, medical image compression is required. This paper mainly focus the preprocesing, image transformation, image compression, encryption, decryption and image decompression. The preprocesing is done MOP of the medical image through RLS filtering. The Hadamard transform is used to transform the image into low level and high level image. The blocks are extracted from the transformed image based on their pixel and then calculate the threshold value for the image. The Hadamard transform on image matrix is to reduce the redundancy from the image. The image compression and decompression is applied on medical image using vector based recursive coding technique. The image encryption and decryption on compressed image is obtained through honey encryption decryption method. The experimental results reveals that proposed image compression then encryption system provides high compression ratio and better bits per pixel compared to existing approaches.

1. INTRODUTION:

In the present world, the usage of internet technology and digital image processing usage is increased. In this process the secure communication of image is important and the without loss of information in image is a challenging task in the image compression. Many researchers focused on only image compression method but they did not consider about the security of the compression image [1-4]. The compression method is divided into two types i.e. Lossy image compression and lossless image compression. The original data or image is correctly reconstructed from the compression data or image is performed by lossless image compression. The lossless or Near lossless image compression is important in medical industry, satellite imaginary and remote sensing. But in the case of lossy image compression, the original data or image is degradable when it reconstructed from the compression data or image.

In medical field the storage of images is important and it takes more bandwidth. The medical images have to be transmitted into different areas in telemedicine application. The medical images such as Magnetic Resonance imaging (MRI), Ultrasound (US), Electro Cardio Gram (ECG), Computer Tomography (CT) and Positron Emission Tomography (PET) have to be stored and is sent to another medical center or expert to check the images. During this transmission the large amount of data or image needs large amount of memory occupation and also it increases the transmission time. Based on the above discussion, the storage of medical image is to be reduced using medical image compression technique. The security is important during transmission because large number of medical information is transmitted. So, the security of the information or data for the respective medical image is obtained through encryption technique.

2. LITERATURE SURVEY

The compression then encryption is done by (**Howard Cheng and XIaobo, 2000**) where the compression is performed by quadtree compression algorithm. After the process of compression, the encryption process was started. In this approach, partial encryption was handled by Set Partitioning In Hierarchical Trees (SPIHT) algorithm. This method is suitable for both video and image processing.

The combined work of independent component analysis and discrete cosine transform was applied for compression then encryption process was developed by **Masonari Ito et al., 2007**. In this process, discrete cosine transform (DCT) algorithm was applied for image compression. The encrypted images are reconstructed by Independent Component Analysis algorithm.

The image compression was performed using Discrete wavelet transform (DWT) applied by **Younggap You and Hanbyeori Kim, 2009**. In this method, the compressed images Were encrypted by standard encryption algorithm AES. This approach was applicable for both video and medical images.

The compression and encryption process was based on fractal coding and spatial architecture was developed by **Thakur and Kakde, 2009**. At the time of compression, the complexity was increased. So inorder to reduce the time complexity of the compression method Fast Fourier transform method based on cross correlation was preferred. The partial encryption method was performed in this process.

Table 1: The existing work of image compression on both lossless and lossy with security

Author	Compression technique	Security method	Key Stream generator	Compression method	Encryption method
Loussert et al. 2008	Lossy	Symmetric	Fingerprint	Discrete Cosine Transform (DCT)	Bit XOR operation
Krikor et al., 2009	Lossy	Symmetric	Pseudorandom	DCT	Selective encryption and Bit Stream Cipher
Nair et al., 2012	Lossless	Symmetric	Pseudorandom bit	Arithmetic coding	Bit-wise XOR operation
Sudesh et al., 2014	Lossless	Symmetric	-	Adaptive compression	Transformation Milline
Xiang et al., 2014	Lossless	Symmetric	-	SPIHT	Selective encryption method
Ou et al., 2006	Lossless	Symmetric	-	DWT	Adaptive Encryption Standard
Alfalou et al., 2013	Lossless	Symmetric	Biometric	DCT	XOR operation

3. PROPOSED FRAMEWORK

The proposed framework provides lossless image compression technique for medical images.

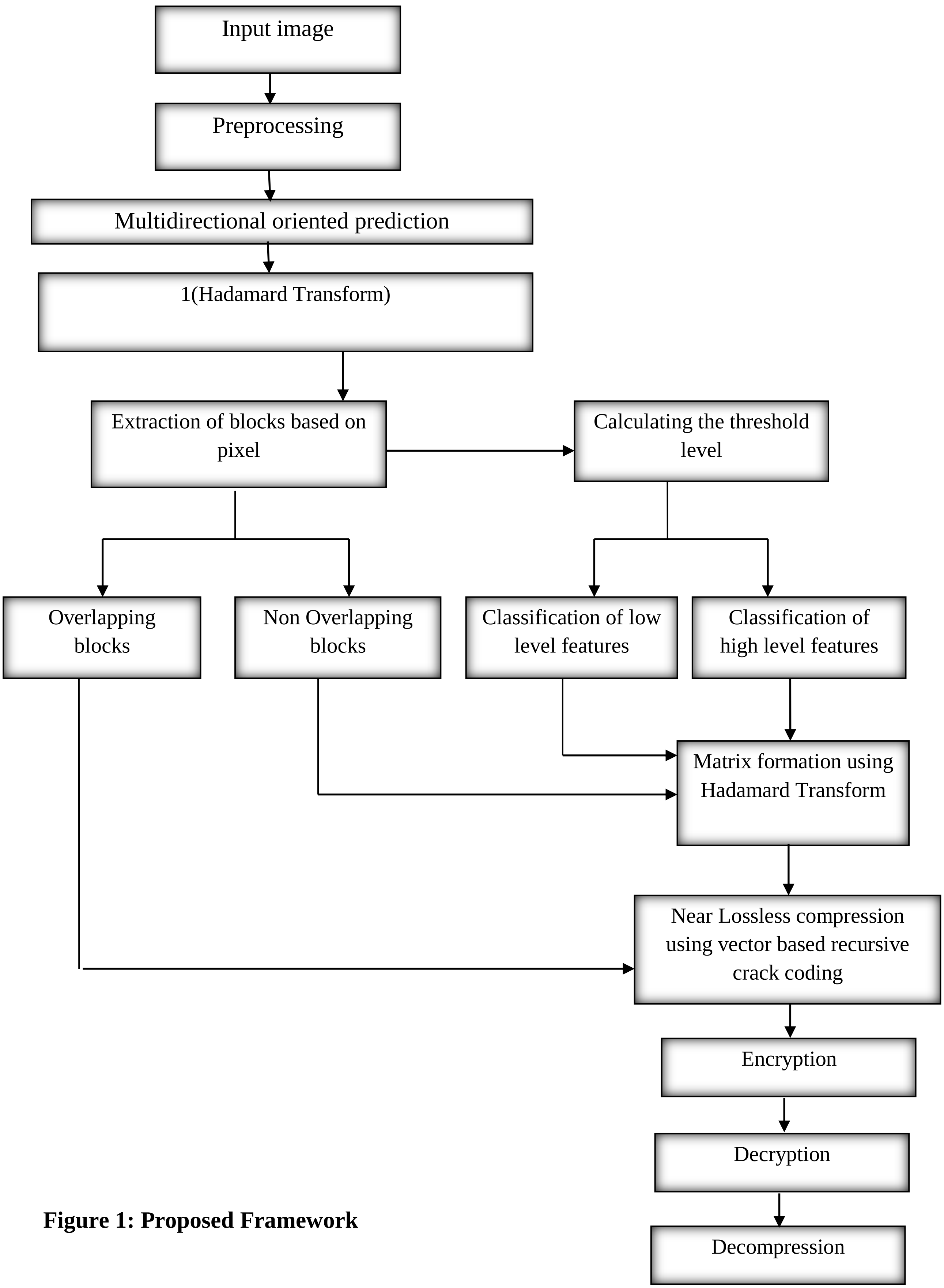


Figure 1: Proposed Framework

The objective of the proposed framework is to provide the security to the compressed image through encryption technique. The proposed framework consists of Preprocessing, Multidimensional Oriented Prediction, Hardamard Transformation, Image Compression, Encryption, Decryption and Decompression.

The medical images are affected by noise during image acquisition, patient movement, and instrumental noise and camera settings. The noise removal is an important process in image compression to predict the information in compressed image. The proposed framework applied Recursive Least square mean adaptive filter for the de noising the medical image.

The adaptive filter is a computational device and it easy to track the variations in the signal or time varying parameter to meet the system performance. The adaptive filter efficiency is based on the design techniques and adaptation algorithm [24, 25]

The RLS adaptive filter provides outstanding performance in a time variable condition [26, 25]. The objective of RLS algorithm is to select the filter coefficients in such a way that the output signal $y(k)$ will match accurately with desired signal in least square estimate [27].

The implementation of RLS algorithm is computed by known initial condition and updates the previous estimation using recent data information [26].

The estimation of least square of filter coefficients is implemented to done this RLS algorithm by $w(n-1)$ at iteration $n-1$ through compute the estimation of coefficients at iteration n through available information [28]. The below equation describes the input vector $x(k)$ with N filter order

$$x(k) = [x(k)x(k-1) \ldots . x(k-N)]^T \quad (1)$$

The equation given below describes the objective function of LS algorithm:

$$\xi^d(k) = \sum_{i=0}^{k} \lambda^{k-1} \varepsilon^2 (i) \quad (2)$$

$$\xi^d(k) = \sum_{i=0}^{k} \lambda^{k-i} [d(i) - x^T(i) w(k)]^2 \quad (3)$$

In the above equation filter coefficients are represented by $w(k) = [w_0(k)w_1(k) \dots . w_N(k)]^T$; the posterior output error is given by $\varepsilon(i)$, forgetting factor is given by λ from $0\ to\ \lambda - 1$. The below equation describes the filter coefficients $w(k)$:

$$w(k) = R_D^{-1}(k)P_D(k) \tag{4}$$

The inverse correlation matrix of the input image is indicated as $R_D^{-1}(k)$ and the cross correlation between the original and desired image is represent by $P_D(k)$.

The computation initialization of RLS algorithm:

$$S_D(-1) = \delta I \qquad (5)$$

Where inverse estimation of the input signal is given by parameter δ.

$$P_D(-1) = x(-1) = [0\ 0\ ..0]^T \qquad (6)$$

$$D_0\ for\ k \geq 0$$

$$S_D(k) = \frac{1}{\lambda}\left[S_D(k-1) - \frac{S_D(k-1)x(k)x^T(k)S_D(k-1)}{\lambda + x^T(k)S_D(k-1)x(k)}\right] \qquad (7)$$

$$P_D(k) = \lambda P_D(k-1) + d(k)x(k)$$

$$w(k) = S_D(k)P_D(k) \qquad (8)$$

Evaluate the following equation if required means:

$$y(k) = w^T(k)x(k)$$

$$\varepsilon(k) = d(k) - y(k)$$

The adapted RLS filtering is applied on the original image to remove the noise as well as for the spectral prediction.

MOP uses six modes of prediction such as Mode 0 (Horizontal), Mode 1 (Vertical), Mode 2(Hybrid) Mode 3 (Π4⁄diagonal), Mode 4(3Π4 diagonal⁄) and Mode 5(Non-Oriented). Non Oriented predictor is optimized for stationary blocks and each of the other five predictors are optimized to predict horizontal, vertical, hybrid, and 45 degree diagonal and 135 degree diagonal oriented edge blocks, respectively.

In this proposed framework, Hadamard transform is used to reduce the redundancy in compressed image as well as remove the blocking artifacts. The Hadamard transform is a symmetric system, separable unitary transformation it has only two elements in its kernel matrix are +1 and -1. The Hadamard transform is existing for $N = 2^n$ in which n represents the integer.

The kernel matrix for these two cases is given below:

$$\frac{1}{\sqrt{2}} H_2 = \frac{1}{\sqrt{2}} \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix} \qquad (9)$$

For larger N, it can be created from block matrix form is:

$$\frac{1}{\sqrt{N}} H_N = \frac{1}{\sqrt{N}} \begin{bmatrix} H_{N/2} & H_{N/2} \\ H_{N/2} & -H_{N/2} \end{bmatrix} \qquad (10)$$

The matrix contains only element that are 1 for size $N = 2^n$, it makes the transform very less expensive.

If N=8, the Hadamard kernel matrix is given as:

$$H_8 = \frac{1}{2\sqrt{2}} \begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & -1 & 1 & -1 & 1 & -1 & 1 & -1 \\ 1 & 1 & -1 & -1 & 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 \\ 1 & 1 & 1 & 1 & -1 & -1 & -1 & -1 \\ 1 & -1 & 1 & -1 & -1 & 1 & -1 & 1 \\ 1 & 1 & -1 & -1 & -1 & -1 & 1 & 1 \\ 1 & -1 & -1 & 1 & -1 & 1 & 1 & -1 \end{bmatrix} \begin{matrix} 0 \\ 7 \\ 3 \\ 4 \\ 1 \\ 6 \\ 2 \\ 5 \end{matrix} \qquad (11)$$

In the above matrix the number of sign changes shown in column to the right corresponding to row. This sign change count is representing as sequence of the row.

The vector quantization scans the original image based on two encoding function, codebook and centroid vector. Due to the computation cost is reduced.

This scanned image is given into recursive crack code for image compression. The below algorithm defines the vector based recursive crack code image compression.

Algorithm 1: vector based recursive crack code image compression

Step 1: Read the scanned original image file

Step 2: The number of rows and columns in the given image is calculated.

Step 3: Separate the row and column pixels as $I[n, m]$

Step 4: For i=1 to n do 5 ## for loop is started (row pixel)

Step 5: For j=1 to m do ## column pixel

Store $I[i, j]$ *and its grey value g as the beginning of the contour*

Mark the obtained pixel $I[i, j]$

$Crack\_Code(I, i, j, g)$

Step 6: The header information is noted and the contour code is noted in another file

Crack_Code algorithm is started

Begin

If $(I[i, j-1]\ equal\ g)\ then\ store\ 0; crack\_code(I, i, j-1, g);$

else if $(I[i-1, j]\ equal\ g)\ then\ store\ 1; crack\_code(I, i-1, j, g);$

else if $(I[i, +1j]\ equal\ g)\ then\ store\ 2; crack\_code(I, i, j+1, g);$

else if $(I[i+1, j]\ equal\ g)\ then\ store\ 3; crack\_code(I, i+1, j, g);$

else return

End;

The encryption and decryption provides the security to the transmission of data in the image compression. The requirement of both encryption and compression to digital images is become popular in recent year to provide the confidentiality to the data and reduce the large amount of data in image compression technique.

In the proposed framework, honey encryption and decryption is applied on compressed image. Honey encryption has the advantage of providing security beyond the brute-force bound over conventional ciphers.

The encryption is done by two steps are:

Step 1: The input message is to encrypted to yield a seed S

Step 2: Under symmetric cipher the encryption process is happened

The DTE then encryption is used for the construction of honey encryption. The setup is given as follows:

- *The distribution over the message space M is denoted by p_m, the distribution over the key space is indicated by p_k, the seed space with the bit length l is given by $S = \{0,1\}^l$ and finally the cipher text is given by C.*
- *The DTE scheme is given as $DTE = (encode, decode)$, the $encode(M) = S$ and $decode\ (S) = M$ in which the M is the message and $S \in S$.*

The following section describes about the decompression from decrypted image.

Step 1: Read the decrypted image file.

Step 2: The number of rows and column in the decrypted image from header is taken.

Step 3: Initialize the row and column of the decrypt compressed image.

Step 4: Repeat the step 5 to 8 until the crack code contour are processed.

Step 5: The starting position and grey value of the next contour is readed.

Step 6: Initialize $I[i, j] = g$;

Step 7: After the initialization the next crack code is to be taken.

Step 8: The present pixel is replaced by $Replace\_Pixel(I, i, j, g, c)$;

Step 9: write the header pixel in one file and store the $I[n, m]$ in another file.

$Replace\_Pixel(I, i, j, g, c)$ *Procedure started*

Begin

if $c\ equals\ 0$ *then store* $I[i, j-1] = g$;

else if $(c\ equals\ 1)$ *then store* $I[i-1, j] = g$;

else if $(c\ equals\ 2)$ *then store* $I[i, j+1] = g$;

else if $(c\ equals\ 2)$ *then store* $I[i+1, j] = g$;

else return;

End

4. RESULT AND DISCUSSION:

The experimentation is done on medical images with standard size. In order to prove the efficiency of the proposed algorithm the performance metrics such as compression ratio, encryption quality, speed performance, Mean Square Error (MSE), Bits per pixel.

The encryption quality is defined by total number of occurrence of each possible grey value in the original I and encrypted image E. The formula for encryption quality is given below:

$$Encryption\ quality = \frac{\sum_{F}^{255}|H_F(I)-H_F(E)|}{256} \quad (12)$$

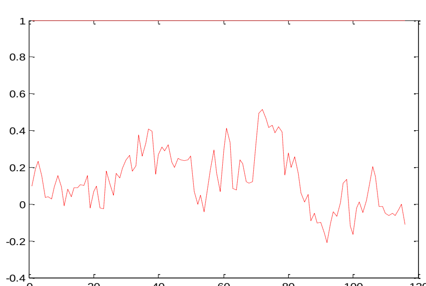
The mean square error (MSE) describes the quality of the image after decryption process. The formula for MSE is given below:

$$MSE = \frac{\sum_{m=1}^{M}\sum_{n=1}^{N}\left[I(m,n)-I'(m,n)\right]^2}{M\times N} \quad (13)$$

Where $I(m,n)$ represents the original image and $I(m,n)$ denotes the decrypted image.

(a)

(b)



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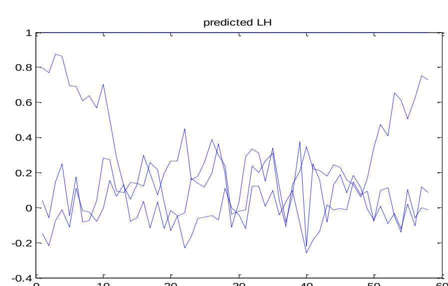
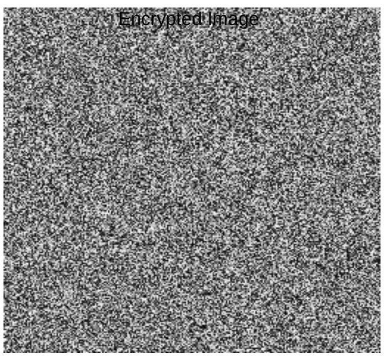


(d)

(e)

(f)



(g)

(h)

(i)

Figure a: Original image

Figure b: Predicted Image

Figure c: Predicted High Level transformation

Figure d: Predicted Low Level transformation

Figure e : Hadamard Transformation

Figure f: Compressed Image

Figure g : Encrypted Image

Figure h: Decrypted Image

Figure i: Decompressed Image

Figure a) illustrates the original medical image. Figure b) shows the predicted image weighted average output is used to remove the redundancy of the ROI of 2-D spatial image. Figure c) & d) shows the prediction of high level and high low level transformation output of redundancy image. The Hadamard transformation is used to removal of artifacts and reduces the redundancy of image is shown in figure e. The given image is compressed by vector based recursive crack coding is illustrates in figure f, the image is compressed through codebook and crack coding process. The compressed image is used to transmit somewhere then the security is important, so the security to the compressed image is obtained through honey encryption and honey decryption method is shown in figure g) &Figure h). The final compressed image is shown in Figure i).

Table 1: Comparison of Compression ratio between proposed and existing image

Images	Huffman coding +AES algorithm	Proposed algorithm
Image 1	1.80	2
Image 2	2.16	2.30
Image 3	1.59	2
Image 4	1.61	2
Image 5	1.56	2

Table 2: Comparison of bits pits pixel between proposed and existing algorithm

Images	Huffman coding +AES algorithm	Proposed algorithm
Image 1	5.924	5.809
Image 2	5.231	4.824
Image 3	4.312	3.834
Image 4	4.891	4.412
Image 5	5.091	4.781

Table 3: Comparison of Mean Square Error between proposed and existing algorithm

Images	Huffman coding +AES algorithm	Proposed algorithm
Image 1	6.35	6.01
Image 2	6.28	5.45
Image 3	6.16	5.73
Image 4	6.34	5.61
Image 5	5.95	5.68

Table 4: Comparison of encryption time between proposed and existing algorithm

Images	Huffman coding +AES algorithm	Proposed algorithm
Image 1	1.0712	1.0612
Image 2	1.451	1.034
Image 3	1.341	1.123
Image 4	1.421	1.231
Image 5	1.541	1.341

Table 5: Comparison of decryption time between proposed and existing algorithm

Images	Huffman coding +AES algorithm	Proposed algorithm
Image 1	0.9123	0.8312
Image 2	0.9456	0.9354
Image 3	0.9871	0.8971
Image 4	1.341	1.1234
Image 5	1.012	0.9821

Table 6: Comparison of Encryption quality between proposed and existing algorithm

Images	Huffman coding +AES algorithm	Proposed algorithm
Image 1	800.23	812.45
Image 2	812.14	823.16
Image 3	901.43	914.57
Image 4	945.11	956.21
Image 5	932.34	943.12

Table 1 provides the comparison ratio between proposed and existing algorithm for five images. From this comparison of compression ratio observed that proposed algorithm provides higher compression ratio compared to existing algorithm.

Table 2 gives the bits per pixel comparison between proposed and existing algorithm. This table shows that proposed algorithm proves better bits per pixel for medical images compared to existing algorithm.

Table 3 provides the quality of image after image decryption given by proposed and existing algorithm. The MSE is calculate for different medical images and it proves that proposed algorithm provides better MSE value compared to existing algorithm.

Table 4 & 5 provides the encryption and decryption time between proposed and existing algorithm. From the table observed that encryption and decryption time of proposed algorithm is less compared to existing approach.

Table 6 gives the encryption quality between proposed and existing algorithm for medical images. For all medical images, proposed algorithm provides higher value than existing method.

5. CONCLUSION:

In this paper considered the problem of near-lossless image compression system using vector based recursive crack coding system. The proposed algorithm addresses image compression method using preprocessing, MOP, image transformation, image compression, image encryption and image decryption. The experimental results shows that proposed algorithm of image compression based on encryption system with Multidirectional Oriented Prediction provides better performance in terms of higher compression ratio, better encryption quality.

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