Hybrid Steganography deployed in hospitals for compression of medical images

V. Avinash, K.R. Sekar, R. Srikanth,
avinash.vijayarangan@gmail.com, sekar_kr@cse.sastra.edu, srikanth@maths.sastra.edu,
School of Computing, SASTRA Deemed University, Thanjavur 613401, India.

Abstract
With the fast-growing technology and emerging innovations in the research arena, privacy and preservation of data predominantly in the medical field are highly essential. At the same time, there is a need for minimized storage of voluminous data in the medical repository. The inspiration for this research work to formulate the hybrid methodologies using improved Steganography, wavelet transform, and lossless compression for privacy and preservation of medical big data images and patient information in the medical big data repositories. The novelty of the work focuses on the preservation of patient's information using enhanced security and optimized big data image storage, which helps the pharmacology professionals to store double the amount of information in the same storage space of the medical big data repository. The secure storage, fast retrieval of image, and minimum computation are the basic ideology of the work. The research work adopts a fast and optimized approach of the Knight Tour algorithm for embedding the patient's data in their medical image and a Discrete Wavelet Transform (DWT) for the safeguarding of the cover image. Furthermore, a lossless wavelet packet compression is applied to minimize the storage size and to maximize storage efficiency. The outcome of the work achieves a higher level of data security without loss in the quality of the image. In addition, the preservation of the reduced size image will be easy to accommodate and can store bountiful images in the repository. A proposed hybrid method of compression in order to get high resolution on spatial and frequency domains will provide an edge.

Keywords: Big medical Data, Data Security, Knight Tour, Steganography, Discrete Wavelet Transform and Lossless Image Compression

1. Introduction

In the recent years, there is a need for medical big data information security in all research areas. One such field where the security of information plays a vital role is the medicine and pharmacology. These days, there has been an increase in the number of diseases and people getting affected by them which arises a potential challenge for storing various information medical big data within a limited storage space. In addition, the security of the information cannot be compromised as well. Through these years, Steganography techniques prove to be one of the effective methods for preserving the privacy of the medical big data. This technique uses a cover image for embedding the data into it in an algorithmic fashion and retrieves it. There are many variations employed in embedding the information into the medical big data image. One such variation used in this paper is the Knight Tour traversal technique combined with the Least Significant Bit (LSB) substitution for data preservation. The patient's big data is inserted into their medical image, which is the cover image for this steganography technique. The insertion is done through the Knight Tour traversal and the binary information is embedded in the LSB position of the medical big data image pixels positioned in the path of the Knight Tour. To increase the security further, we used a Discrete Wavelet Transform (DWT) for the cover image to make it unreadable and a lossless wavelet packet compression for efficient storage of the transformed image in the medical big data repository. This hybrid approach not only provides data security for the patient's information but also effectively stores their data in the medical big data database using minimal storage space.

2. Literature Survey

The literature gives the details reports shows different methods and guidelines towards the of steganography. The result suggests some useful recommendations and advises to go with the object-oriented mechanisms [1]. The tri-layer technique involving the pixel statistics conservation, Moore Space Filling Curve and Hilbert Space Filling Curve to improve and enhance the security level [2]. The research article presented a detailed comparative analysis among various digital steganographic techniques and the effectiveness is estimated with the PSNR and MSE values [3]. The wavelet transform provides the images of black and white for image compression, which uses LGB algorithm and error correction method to minimize distortion. The outcome of the compression is compared with many other techniques [4]. The focussed methods dwt, coupled map lattices(CML) for data encryption. The results shows that the presented encryption algorithm has the advantages of large key space and high security, and fast encryption/decryption speed[5]. For investigation. The JP3D framework supports in compression more optimal manner about the medical images with the new developed routines of JDEG 2000. Generic intra band mode predictions and various bidirectional wavelet transforms were used in the compression techniques and setting, guidelines were followed for optimal volumetric image compression with acceptable complexity measures. The proposed a low complex 2D image compression method using Haar wavelets and quality of the compressed image is tested. The quality of the compressed images has been evaluated using some factors like Compression Ratio (CR), Peak Signal to Noise Ratio (PSNR), Mean Opinion Score (MOS), Picture Quality Scale (PQS) etc.[7]. The paper adopted a simple LSB substitution technique to hide the data. The MSE is calculated and the resulting image has no significant change from the original image [8]. For utilizing an improved Steganographic technique involving the side information by measuring the distance between the pixels and smoothness to estimate the degrees and it is needed to accommodate the images in large quantity with small distortion [9]. The applied steganography of random pixel selection in DWT domain correlation and permutation with a cryptography technique provides confusion and dispersion [10]. The work presents a data hiding scheme by adjusting the LSB value of the color pixel intensity by doing a simple binary addition and the outcome proves that the embedding capacity is twice higher than the traditional technique [11]. The methods used were DWT for medical image compression. involving Multi-Pixel Differencing(MPD) and Lest Significant Bit (LSB) substitution to enhance the quality of the image and increasing the capacity of the data storage. The results show the enhanced image and resolution is not disturbed[12].Using the pooling Single Value Decomposition (SVD) and optimized Discrete Wavelet Transform (DWT).Also Huffmann encoding and decoding is performed. The results are compared with other image compression methods based on CR, PSNR, SSIM, MSE [13]. It presents a book containing various techniques of Steganography and Digital watermarking for the beginners. This acts as a guide for all the people to understand the concepts and implement it very easily [14]. The applied the 2-D orthogonal wavelet transform and the transformed image coefficients were coded and quantized in accordance with the local estimated noise sensitivity of the human visual system (HVS). The technique provides high compression ratios [15]. Accomplished the medical big data Image compression, fusion and encryption are simultaneously using CS, chaos and Fractional Fourier Transform. The proposed scheme reduces data volume and simplifies keys. The proposed scheme reduces data volume and simplifies key[16]. Secure watermarking images and DWT, DCT were preferred for data patient data privacy of the big medical database. The performance evolution consist of PSNR were measured through correlation to know the degradation of the image [17]. Suppose to send the images in a unsecured network it always having very fast transmission without any loss in the pixels. The most significant algorithms were proposed to ensure the fast transmission of the images for that purpose DWT is appreciated [18]. Wavelet based approach to compress as well as encrypt the fused images by selecting significant and less significant information. The fusing is done using error measurements and maximum method while the compression and encryption methods pseudo random number sequences and Huffmann coding. The results show that the proposed method is superior over all others[19]. The DWT for medical big data image compression. The proposed algorithm having higher performance and security in the image compression as compared to the earlier works[20]. The paper adopts the methods DCT and watermarking to store patient information. The results show that the proposed scheme achieves better performance of imperceptibility[21].Uses a modulus operation and achieves many advantages by gaining good resolution overcoming LSB substitution and High storage area to achieve a high hiding capacity[22].To taken up an improved Embedded Zero tree Wavelet technique to produce an successful method for low bit rate and high compression ratio, and improved EZW techniques for lossy and lossless compression applications of greyscale and colour images[23]. The paper proposed a simple and an optimized LSB substitution method along with the genetic algorithm to embed the image. The results show that the embedded image will not be seriously affected and the hiding strategy is improved[24]. The presents and applied a novel steganography approach by using replacement of LSB and Pixel Value Differencing method were proposed. The proposed method improves image quality and maximizes the space for hiding[26].

3. Proposed Methodology

The proposed methodology mainly focuses on Knight Tour Steganography, Wavelet Transformations and compression. The fast Knight Tour approach is designed to traverse only in the forward 'L' direction that is, three down and one right starting from the first pixel of the image. The cover image is transformed using DWT and lossless wavelet packet compression ‘wpdencmp‘ based on ‘haar’ wavelet is applied to compress the transformed image. The complete methodology is depicted in the following Architecture diagram.

3.1 Architecture Diagram

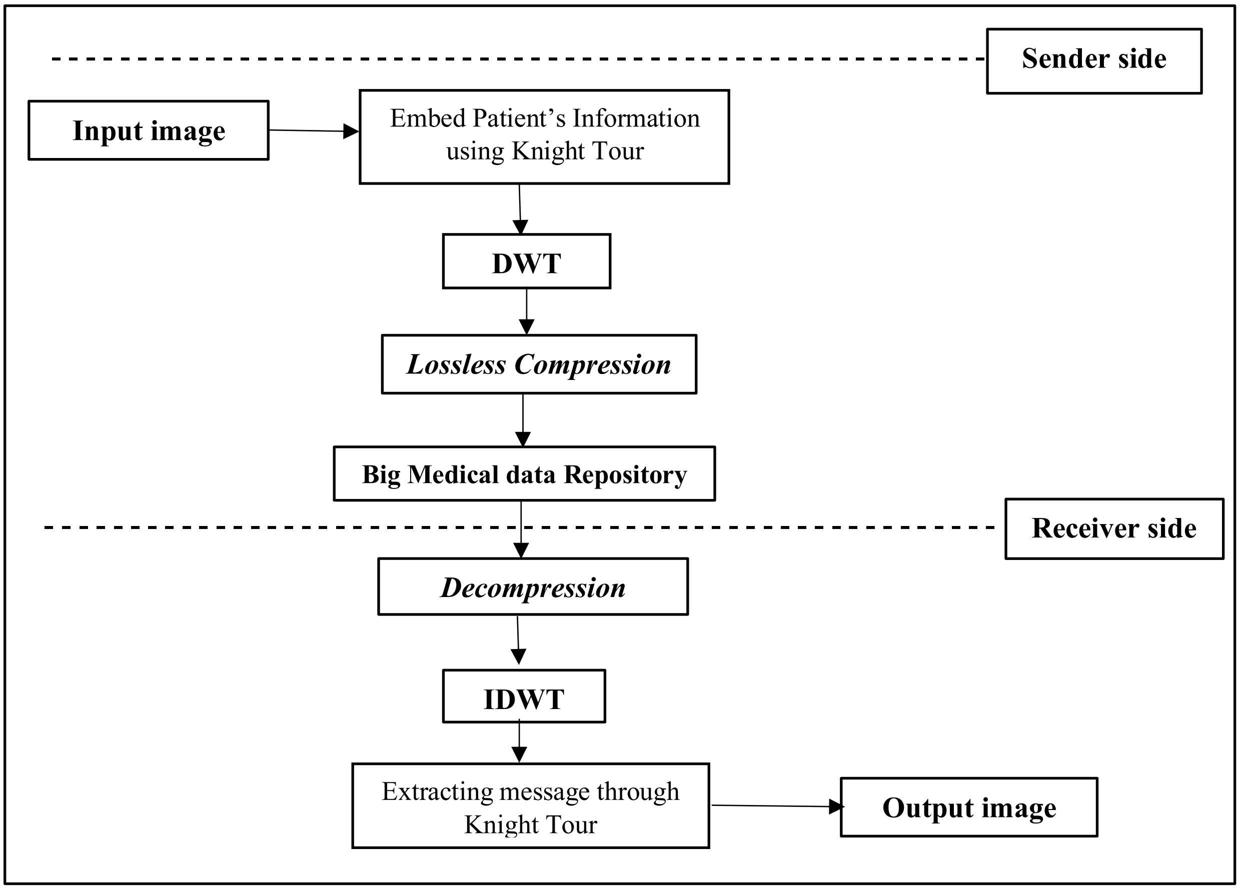

Fig1. Overview of the architecture

3.2. Proposed Algorithm

Improved Embedding Algorithm

Step1. The medical image is loaded and the patient data is taken.

X ← medical image

D ← patient data

Step2. Since fast Knight Tour requires 3 rows and 2 column, the matrix dimensions are adjusted in such a way that the rows are of multiples of 3 and columns are of multiples of 2. The extra row or column added is padded with the value ‘256’ as the pixel ranges between 0-255.

Step3. The ASCII value of the patient data is extracted and converted to its equivalent binary value.

D → ASCII (D) → Binary(D)

Step4. Knight Tour is employed for pixel traversing of image in ‘L’ path and the LSB bit of each pixel is changed with each bit of the binary value from patient data.

```
        for i = 1 to number of rows
          for j=1 to number of columns
            if  X ( i+2, j+1 ) ~ = 256
    l= j
```

```
            for h=i to i+2
    t=X(h, l)
    LSB ( t) = D ( bit )
          X (h,l)= t
    end
            t = X (h,l+1 )
            LSB ( t ) = D ( bit )
                X (h,l+1)= t
    end
    end
end
```

step5. Delete the extra paddedrow or column

step6. Extract the red, green and blue components from X

red←*X*(:,:,1);

green←*X*(:,:,2);

blue←*X*(:,:,3);

step7. Apply forward Discrete Wavelet Transformation for the red, green and blue components using the formula

$$I_{DWT}(a,b) = 2^{-a/2}\int_{-\infty}^{+\infty} i(t)\psi(2^{-a}t-b)dt \quad \text{-----(1)}$$

$$\psi_{a,b}(t) = 2^{-a/2}\psi(2^{-a}t-b) \quad \text{-----(2)}$$

where $\psi(t)$ is the mother wavelet

step8.Combine the individual transformed components into one matrix.

trans ← combine (red, blue, green)

step9. Compute lossless wavelet packet compression using 'wpdencmp'function with 'haar'wavelet packet

Z = Compress (wpdencmp, trans, haar)

step10. This compressed is stored in medical repository.

Extracting algorithm

step1. Retrieve compressed image from medical database and perform wavelet decompression compressed image

trans ← Decompress (Z)

step2. Apply Inverse Discrete Wavelet Transformation (IDWT) using the formula

$$i(t) = \sum_a \sum_b I_{DWT}(a,b)[2^{-a/2}\psi(2^{-a}t-b)](3)$$

step3. Extract the red, blue, green components from the reconstructed image, combine them to get the actual image.

step4. To make the image matrix traversable, extra row or column is added and padded with the value '256', as the pixel ranges between 0-255.

step5. Same Knight Tour is used to extract the LSB values from the pixels of the image traversing in 'L' pattern.

```
 for i = 1 to number of rows
        for j=1 to number of columns
          if  X ( i+2,  j+1 ) ~ = 256
    l= j
            for h=i to i+2
              t = X (h, l )
             D ( bit ) = LSB ( t )
                end
            t = X (h,l+1 )
            D ( bit ) = LSB ( t )
    end
    end
```

end
step6. Delete the extra padded row or column
step7. Convert the obtained binary bits to ASCII values and to the character.
Binary (D) → ASCII (D) → char (D) → D
step6. Patient data ← D
Medical image ← X

4. Results and Discussions

The overall methodology of this paper comprises of Knight Tour steganography, DWT transformation and lossless wavelet packet compression of the medical images for data privacy, preservation and efficient storage. The Steganography technique employed here uses LSB substitution technique that changes pixel's LSB bit with the patient's data in binary format. The result of the steganography method depicted in fig2, shows that changes in both cover image and stego image are indistinguishable. This reveals that the LSB substitution method is formidable in the field of steganography. After this, the obtained stego image is transformed to provide unreadability of the images and a compression technique is employed for the better storage of medical images in the database. This scenario can be seen in fig3. The picture shows the transformation, compression, decompression and inverse transformation processes in a sequential order. To realize this methodology, a brain haemorrhages image that was already embedded with the patient's data is taken as an input and Discrete wavelet transformation is applied to get a transformed image. The method 'dwt2' is used for the transformation. In the DWT process, the original image is decomposed up to 2 levels using 'haar' wavelets. This decomposition produces horizontal, vertical, diagonal and approximation components. To regain the original image, the decomposed components are reconstructed using the inverse Discrete wavelet transformation. The method idwt2 is used for this purpose. This strategy is visualized in fig4.

For the compression method, the decomposed image is taken as input and compressed using wavelet packet compression technique utilizing 'haar' wavelet packets. The employed compression methodology 'wpdencmp' uses the soft thresholding technique that compresses the image using wavelet packets and computes a threshold value. The concept of this compression is depicted in fig.5 along with the histograms of original and compressed images. The step-by-step compression process is visualized in fig.6. At each level the image is refined and the difference among the levels is clearly visible. More the number of encoding levels of compression, higher would be the compression ratio and recovery energy of the image. The compressed image is then decompressed by wavelet packet reconstruction using the book-keeping matrix values of the decomposed image. The horizontal, vertical, diagonal and approximation components are taken from the decompressed image and inverse Discrete wavelet transformation is applied to retrieve the original image. In fig2. The cover image embedded with the patient's data is visualized.

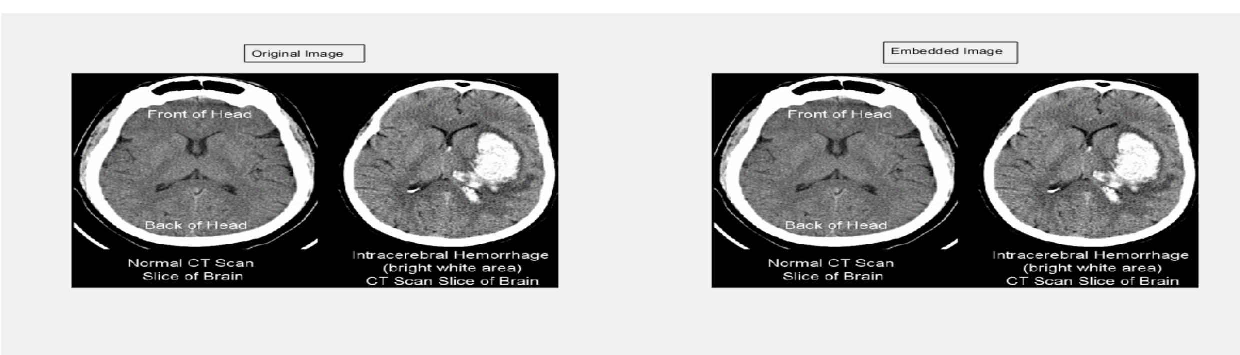

Fig 2. Embedded Image

In fig3, the stego image of the brain haemorrhage is taken and DWT is applied. After compression, the compressed image is displayed as a bar graph. The decompressed image is recovered from the compressed image by wavelet reconstruction method. The target image is retrieved from the decompressed image by applying the IDWT method to the previous step.

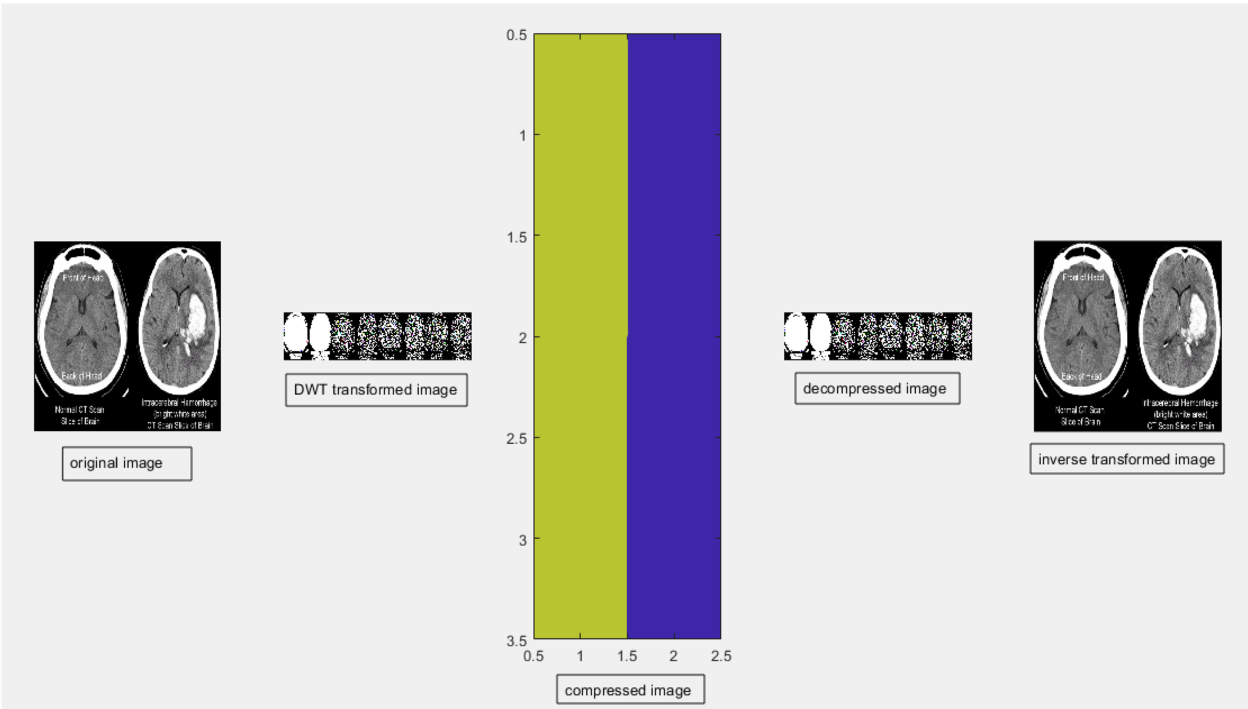

Fig 3. Transformation and Compression

Fig.4. represents the Discrete wavelet transform and Inverse Discrete wavelet transform of the brain haemorrhage image. A sample segmentation of the transformed image is also displayed.

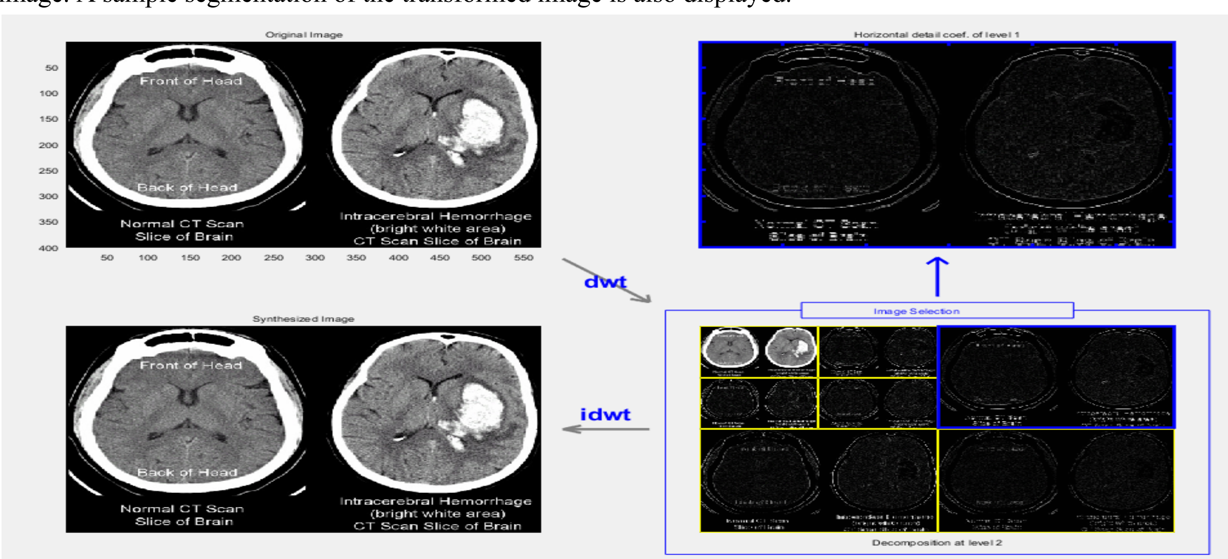

Fig 4. Discrete wavelet transform

Fig.5. represents the histograms of the stego image, decomposed image and compressed image in red, blue and pink colours respectively. The obtained outcome shows that the adopted methodology is efficient in loss-less compression of medical images with high resolution. In the depicted picture below, the novelty of the work is available that gives the great ornament and enhancement of our proposed methodology using improved wavelet transformations and lossless compressions.

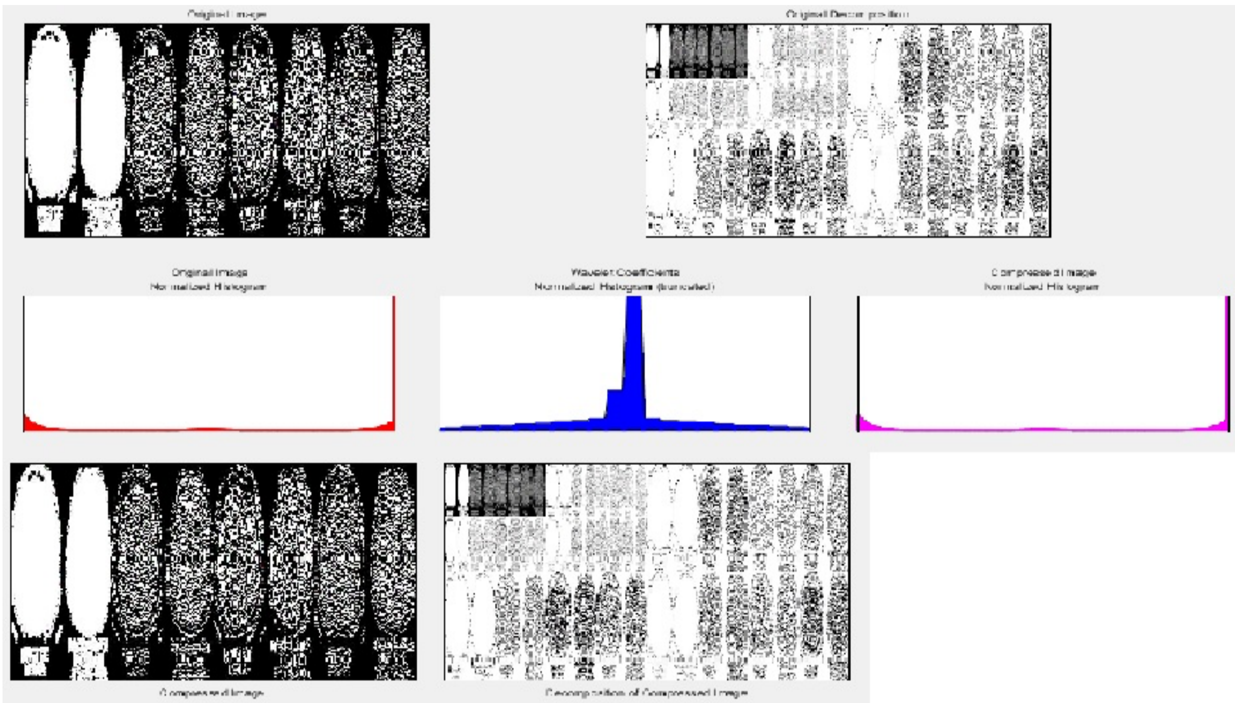

Fig 5. Histograms of original and compressed images

Fig 6. represents the transition steps of the wavelet packet compression technique. Each images are clearly distinguished from one-another.

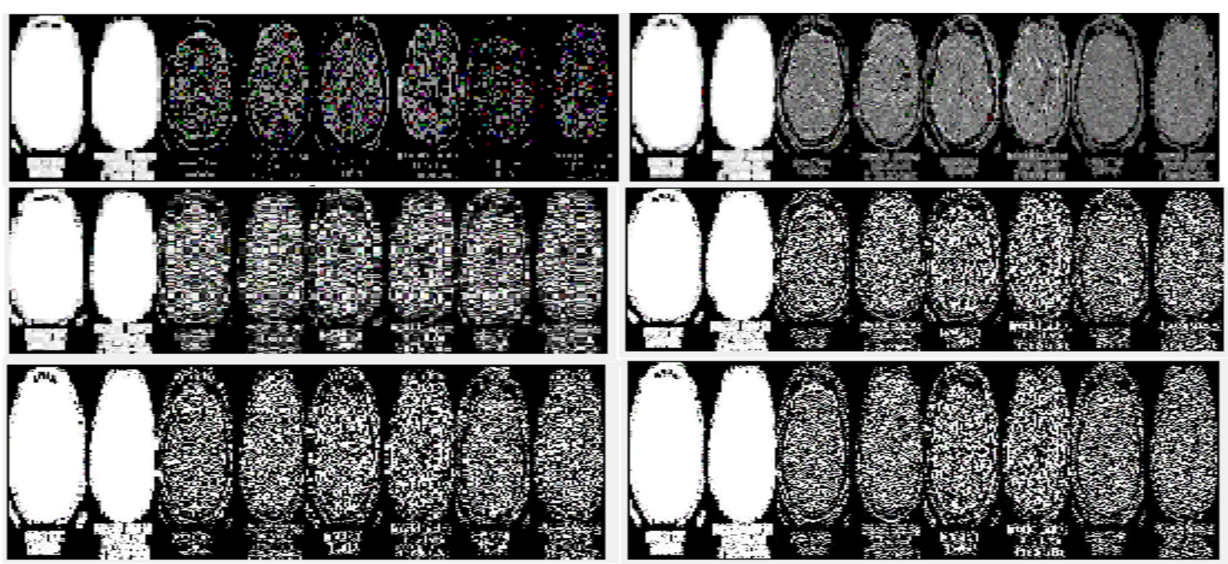

Fig 6. Step-wise compression of transformed image

5. Comparative study

The decompressed image is compared with the original image and the following parameters are evaluated.

Table1. Comparative Analysis of Image parameters

Message to embed / Properties	"BuddhaSmiledWholeHeartedly"	"BuddhaSmiled"	"Bud"
Mean Square Error (MSE)	41.8807	41.8802	41.8802
Signal to Noise Ratio (SNR)	25.7952	25.7953	25.7953
Peak Signal to Noise Ratio (PSNR)	31.9107	31.9107	31.9107
Structural Similarity Index (SSIM)	0.9914	0.9914	0.9914
Bit Error Rate (BER) Number, ratio	1548, 7.38%	1548, 7.38%	1548, 7.38%

The study reveals that, when the information size increases, there is no significant change in the evaluation parameters. This gives the insight that no matter the size of the information, the error rate will be small enough which does not create any distortion in the stego image or the decompressed image. Similarly the proposed method is tested with 43,752 chest X ray images from the National Institutes of Health – Clinical Centre (NIHCC) database consisting of 100,000 images including associate details and diagnosis information [25] and from other publicly available datasets as well. These medical big data image datasets are available for the public usage and can be located and benefited from the URL http://www.aylward.org/notes/open-access-medical-image-repositories. The testing of 43,752 images gave the expected results with various data modifications and alterations such as including additional data for challenging the embedding algorithm and to inspect the effectiveness of the compression algorithm. No matter the changes introduced in the input data, the embedding and the compression algorithm does not deviate from its expected outcome and proves their robustness and accuracy for any amount of data and the introduced gimmicky challenges. Also the compression ratios for all the images exceeded the 80 percent bench mark which indicates high compression of images with no loss in compression. Out of the original 17.58 GB of medical big data dataset the overall compression achieved is 8.64 GB which is very efficient for the storage in medical repository. This proven results gave us a clear insight into how well the hybridization and conglomeration of these techniques resulted and gives an enormous boost and inspiration for working with these well-put-together technique.

6. Hybrid compression

A lossless image compression primarily uses DWT. The proposed method provides compressed images that are of higher spatial resolution and lower frequency resolution on sub bands. We need to improve frequency resolution on the sub bands so that Discrete Cosine Transformation (DCT) will be applied to compress on sub bands. This kind of hybrid setup like DWT-DCT will enhance the quality of compressed biomedical images. The following 4 components are properly executed on any image, we will obtain high resolution in both domains (while online transaction takes place): 1. {Spatial domain compression on image spaces - DWT} 2. {Frequency domain compression on Sub bands – DCT} 3. Encryption of image and 4. Error control of image. It is derived that hybrid compressed image y = Convolution mapping of f(spatial domain - DWT) and g(frequency domain on sub bands – DCT) before the encryption takes place. The major issue lies on segregating sub bands from a given image. All sorts of computation, filtering, transformation, compression, encryption and error control are executed in the proposed hybrid method with respect to time complexity O(n). For big data of medical images of patients, the proposed hybrid compression is helpful in hospitals.

7. Evaluation Study

The process of Steganography, transformation and compression of images can be done on any platform by using any of the methods. But achieving higher security and minimal storage is important. So choosing an efficient and effective methodology helps for gaining best results. The selection of optimized and fast Knight Tour for Steganography and Discrete wavelet transformation along with wavelet packet compression of images helped to achieve better results. To show the success of the proposed method, the experiment is carried out in a platform called MATLAB with the version R2017b, where the work ofdata embedding, transformation and compression is done. The MATLAB software acts as tool for performing all the mathematical operations as well as give very accurate results in each step. Windows 10 operating system is used to provide a great support for performing a productive and skilfull research. The Knight tour gives an innovative flavor for the steganography technique and the transformation helps in protecting the stego image. In addition, the transformed image is compressed using lossless compression and again decompressed in the receiver side with the same resolution of original image. This shows that the compressed image can be stored in the database with less storage space and helps in effective storage.

8. Conclusion

In the research article, the brain haemorrhage image was taken and it was embedded with the patient's data. The embedded image was transformed using the Discrete Wavelet Transformation with 'haar' wavelets. Then the transformed image was compressed using the 'haar' wavelet packet compression. The image was compressed to 83.3333% and it was decompressed and reconstructed to retrieve the embedded stego image. This retrieved stego image was then used to extract the patient's data and the original image. The resolution of the explored image after decompression was never disturbed and moreover, since there is no loss in stego image, the extracted patient information is not altered. The optimization obtained through the test was very helpful to store and preserve the medical image in the repository for long period of time without compromising the privacy of the patient. The compression technique provided a stunning lossless image after decompression which was very useful in retrieving the patient's information. The research work guaranteed preservation of medical images in the repository in an optimized way and privacy is enhanced.

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