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ENHANCING THE PERFORMANCE OF COMPRESSION RATIO FOR SYMMETRY BASED BIOMEDICAL IMAGES

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Abstract: - Image compression is the art of reducing the amount of redundant data required to represent an image in an efficient form. This project is about enhancing the performance of compression ratio for Biomedical images. In this work symmetry plays a vital role. Symmetry is nothing but the quality of something that has two sides or halves that are the same or very close in size, shape, and position. It is implemented by SIFT algorithm and the encoding technique used in this work offers great potential in complete lossless compression of the biomedical images. This method comprises getting rid of the redundant data and encoding the non-redundant data for the purpose of regenerating the image without any loss of data. Angular transform also called arcsine transform which converts the pixel values into its corresponding phase values for the purpose of compression. Bit plane coding is used in this work because of attaining higher compression ratios. Angular Transform and Bit plane encoding scheme with symmetry which are used in this project is studied, implemented and tested with various MRI and CT images. It provides the efficient compression ratio with less amount of computational complexity.

Keywords: Symmetry; Biomedical Image Compression; SIFT; Zig-Zag Mapping; Angular Transform, Bit Plane Coding.

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1. Introduction

In this work, symmetry is used as a parameter for compression of bio-medical images [2]. Symmetry is exact similarity of position or forms about a given point, line, or plane. The medical images, which are symmetric about vertical axis (by crude observation), has an opportunity to compress it using symmetry as a parameter. The image data present in both halves of this image is almost equal barring a few pixels. Thus, if data from only a single half along with differential information of other half is transmitted, instead of transmitting both halves, then substantial amount of compression can be achieved. The first task is to obtain the dominant axis of symmetry for any kind of image. The axis will act as a differentiating detail between the two halves of the medical image.

After finding the axis of symmetry, it is then rotated at 45 degree for applying zig-zag coding, then the axis is aligned at the diagonal. Based on this symmetry axis the image get separated into two divisions as lower array and upper array using zig-zag coding which is used to store the image matrix into a vector. In previous work Huffman coding is used as source encoding. In this work it employs Angular Transform and Bit plane slicing as a source encoding for better image compression with less amount of computational complexity.

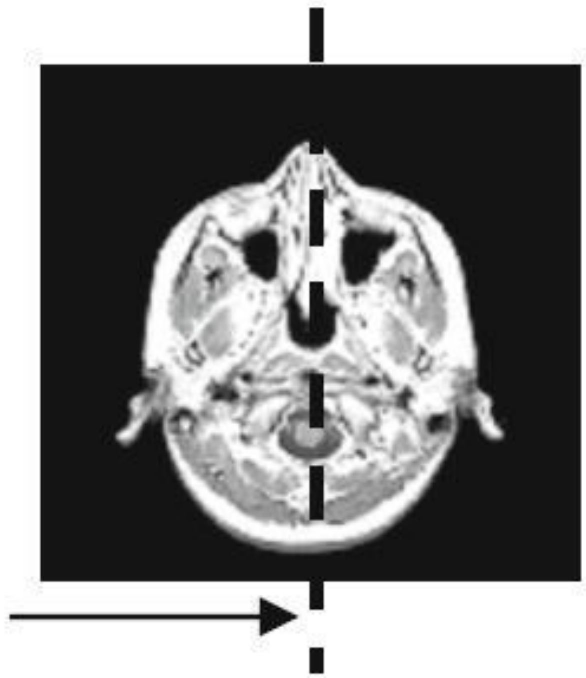


Fig.1.1 Symmetric Biomedical Image of Human Brain

2. Existing Work:

There are several common techniques that have been adopted in the literature to perform this redundancy reduction step including Differential Pulse Code Modulation, hierarchical interpolation, multiplicative auto regression. Several popular approaches for encoding are Lempel-Ziv encoding, arithmetic encoding, run-length encoding and Huffman encoding. Existing work used Huffman coding for the compression of Biomedical images.

Advantages includes in this existing work are Lossless compression up to 50 %., Better compression ratio Robustness and at the same time there are some disadvantages are there. It includes Time consuming during process and it is a challenging task to achieve satisfactory amount of compression without losing any content of the image and maintaining the diagnostic ability of the image.

3. Proposed Work:

The algorithm used in this case is compatible with medical images having any rotation, orientation. The biomedical image in any format, preferably DICOM format is applied to the algorithm [4]. There is a need to find the axis of symmetry for further processing, for compressing the image using symmetry as a parameter. The main challenge is to find the axis of symmetry of actual image object the main informative part excluding background and not the geometrical axis. The actual object of image may not lie on the central geometric axis also it may have small angle with respect to the central geometrical axis.

The choice of encoding technique is of utmost important when implementing any of the compression algorithms. The encoding method should be elegant, less complex and fast, and should give accurate results. In case of medical images, the required feature is that the technique must be lossless and optimized or the removal of symmetric redundancies as presented in this work. It uses better compression technique called Angular Transform and Bit plane coding for better image compression [11]. It provides better compression ratio when compared to existing work with less amount of computational complexity. Advantages of using this methodology are as follows:

- Provides better compression ratio than existing work.
- Compression ratio of Bit plane encoder is enhanced
- High performance
- Robustness

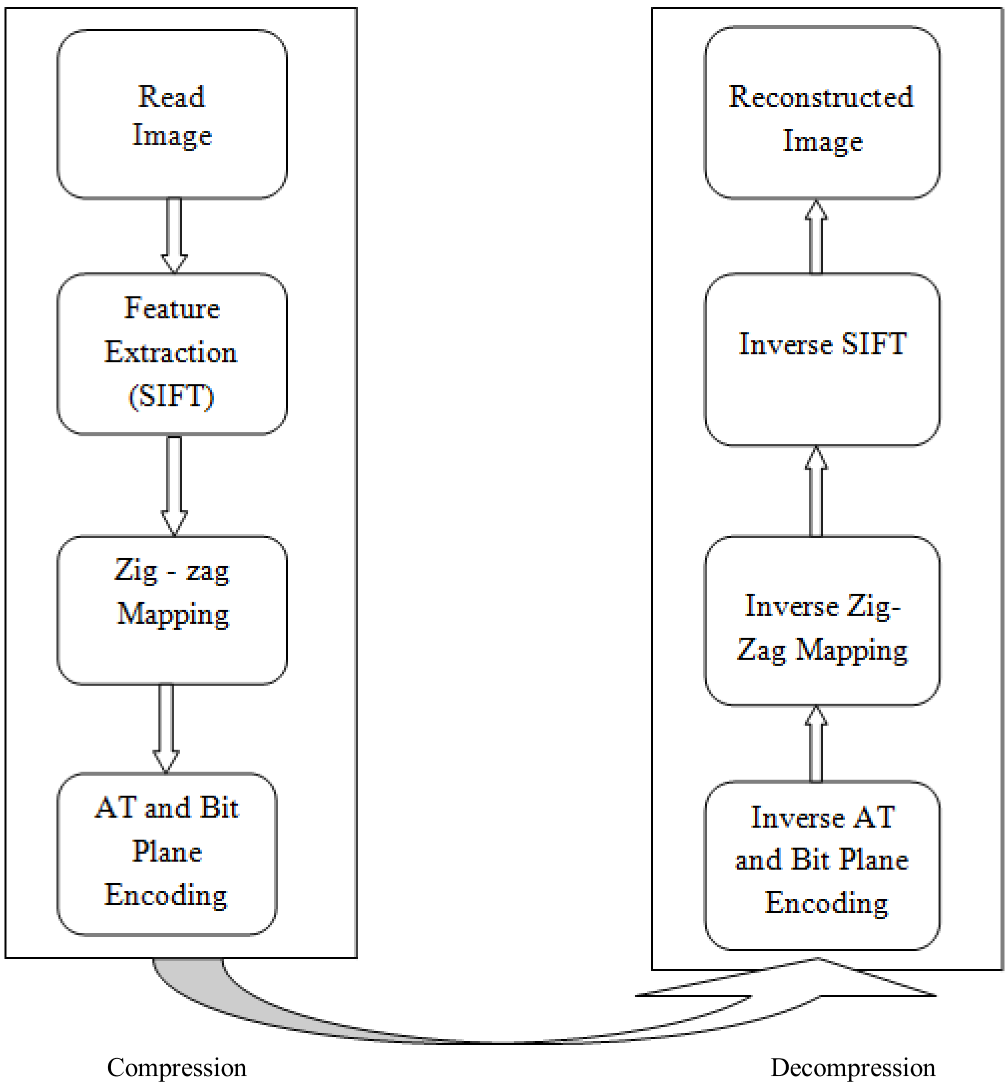


Fig.3.1 Block Diagram of Proposed Work

Proposed work includes the following modules they are

- Feature point Extraction
- Zig-zag algorithm
- Angular Transform
- Bit Plane Coding

3.1 Feature point Extraction

3.1.1 SIFT Apply image to symmetry module to get axis of symmetry. The SIFT (Scale Invariant Feature Transform) operator is used here and based on the feature points obtained from this algorithm, the axis of symmetry is determined [14]. The scale-based technique basically is used to limit the number of symmetric matches for a particular feature vector. A set of feature points „pi‟ are determined using any rotationally invariant method such as SIFT which detects distinctive points with good repeatability.

The point vector pi=(xi, yi, i, si) is assigned to each feature and stores the information such as the location coordinates, orientation, and scaling data. A set of mirrored feature descriptors is generated. Here, „mi‟ describes a mirrored version of the image patch associated with feature vector „ki‟. The mirrored feature descriptors mi can be generated in one of two ways.

The feature detection and matching to be treated entirely as a Black box is to flip the original image about the y (or x) axis and compute the feature point descriptors for the mirrored image. Each mirrored feature point can then be assigned to the corresponding feature point in the original image, so that „mi‟ is the mirrored version of the vector „ki‟.

Reordering the elements of the descriptor vector so they represent the original image patch flipped about the axis aligned with the dominant orientation.

Matches are then sort between n the features „ki‟ and the mirrored features „mi‟ to form a set of (pi,pj) pairs of potentially symmetric features. Each pair of symmetric features generates two matching pairs, but as these matches are equivalent only one need be recorded. The symmetry of each pair is quantified as a function of the relative location, orientation, and scale of pi and pj.

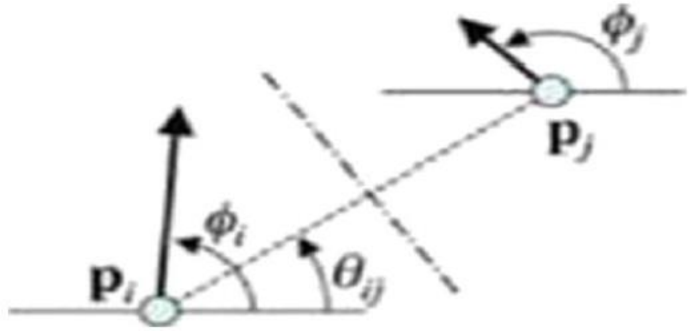


Fig.3.2 Mirror Symmetry Under Scrunity

The angular symmetry weighting $\varphi_{ij} \in [-1,1]$ can be computed as,

$\varphi_{ij}=1-\cos(\varphi_i+\varphi_j-2^{(\theta_{ij})})$

Where,

φ_i = angle of featured point

φ_j = angle of mirrored point

φ_{ij} = angle of featured pair

A scale weighting Sij ∈ [0, 1] quantifying the relative similarity in scale of the two vectors is computed as

$$S_{ij} = \exp\left(\frac{-|S_i - S_j|}{G_s S_i - S_j}\right)^2$$

Where, Si = scale weight of featured point

Sj = scale weight of mirrored featured point Gs = controls the amount of scale variation There might be multiple axes possible in single image, but only one will be accepted as a major axis of symmetry. Matching pairs that are closer to the symmetry axis are taken in to consideration. To measure the similarity between feature vectors, the Euclidean distance between the SIFT descriptors has been used.

Computation searches over all scales and image locations. It is implemented efficiently by using a Difference-of-

Gaussian (DOG) function to identify potential interest points that are invariant to scale and orientation. Key points are selected based on measures of their stability. One or more orientations are assigned to each key point location based on local image gradient directions.

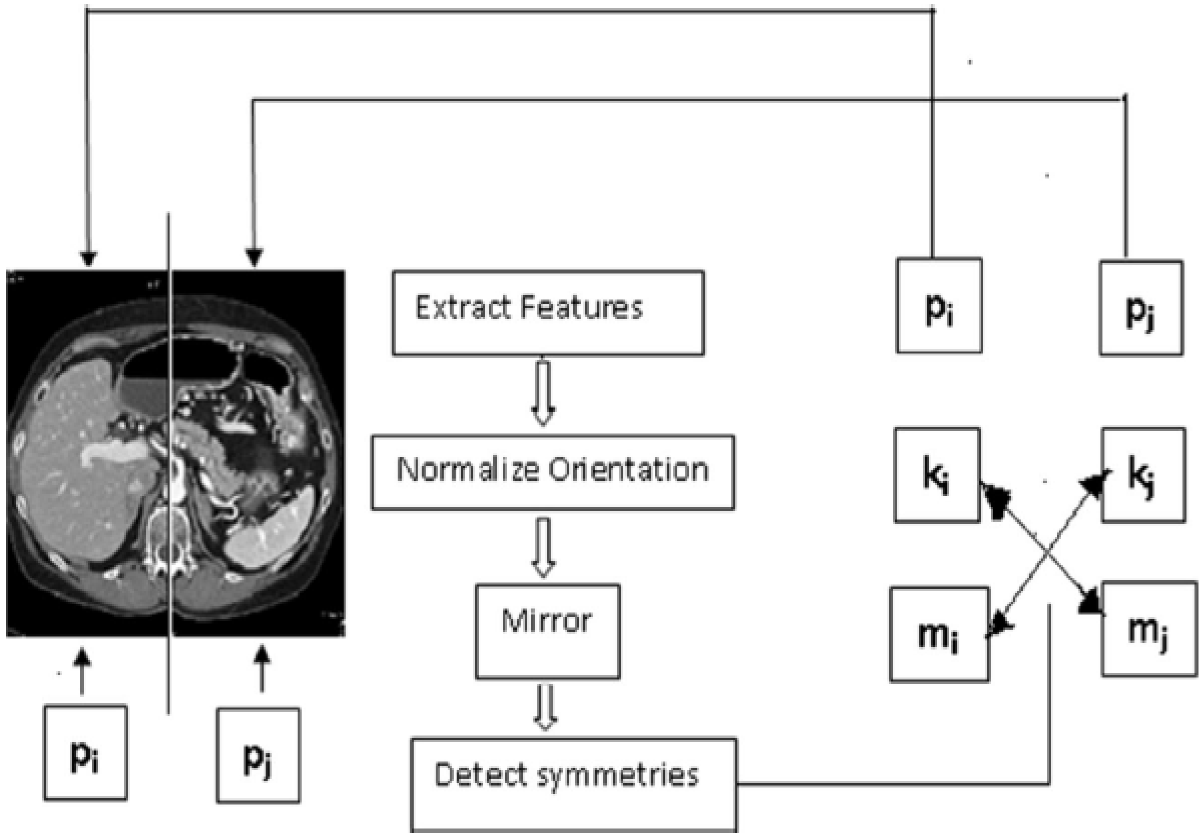


Fig: 3.3 Schematic Illustrating the Extraction and Matching of a Pair of Symmetric Features

The linear Hough transform can then be used to find dominant symmetry axes. Each symmetric pair casts a vote in Hough space weighted by its symmetry magnitude. The points lying in the neighborhood of these maxima in Hough space indicate the symmetric pairs that are associated with this particular axis of symmetry. Finally find the symmetry axis.

3.1.2 Hough transform

The Hough transform is a feature extraction technique used in image, computer vision, and digital image processing. The purpose of the technique is to find imperfect instances of objects within a certain class of shapes by a voting procedure. This voting procedure is carried out in a parameter space, from which object candidates are obtained as local maxima in a so-called accumulator space that is explicitly constructed by the algorithm for computing the Hough transform. The classical Hough transform was concerned with the identification of lines in the image, but later the Hough transform has been extended to identify positions of arbitrary shapes, most commonly circles or ellipses.

In this work, the dominant axis of symmetry is detected by Hough transform can be calculated by the formula,

r = x cos θ + y sin θ
Where, r = distance from the origin to the closest point on the straight line
θ = angle between the axis and the line connecting the origin with that closest point.

3.2 Zig-Zag algorithm

The need for aligning the axis along the diagonal is to apply the zig-zag algorithm (vertical raster scan) within the lower triangle and upper triangle. The zig-zag encoding is vital for this algorithm because the basis of this algorithm is the separation of image into two halves based on the axis of symmetry and storing these two halves into different vectors can be achieved through zig-zag encoding [2]. Arithmetic encoder is used which is more efficient than normal encoders like RLE in terms of higher compression ratios. But when compare with the bit plane slicing technique it provides the better compression ratio with lesser loss of data.

The JPEG standard also allows but does not require decoders to support the use of arithmetic coding, which is mathematically superior to Huffman coding. However, this feature has rarely been used as it was historically covered by patents requiring royalty-bearing licenses, and because it is slower to encode and decode compared to Huffman coding. Arithmetic coding typically makes files about 5–7% smaller.

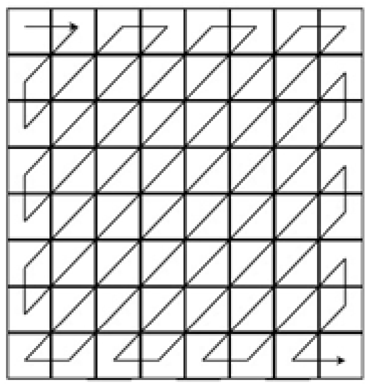


Fig: 3.4 Zag-Zig Ordering

3.3 Angular Transform

Angular Transform is also called Arcsine transform which converts the pixel values into respective phase angles. This can be done by the following two steps:[14]

• Normalization
• Arcsine Transform

3.3.1 Normalization

Normalization is the process of converting the range of pixel intensity values. It can be calculated by the formula as follows:

Qij = (Pij - Pmin) / (Pmax - Pmin)

Where, Qij = Normalized Image
Pij = Original Image
Pmin = Minimum gray level value
Pmax = Maximum gray level value

3.3.2 Arcsine transform

It is the process of taking inverse sine function. It is also called as Inverse sine transform. This can be calculated by using the formula,

Qij‘‘ = sin-1(Qij)

Where, Qij“ = Angular transformed Image The sine transform has the property that for two different angles, it has same gray level value. Since we know the inverse sine function is represented by sin-1 which is defined to be the inverse of the restricted sine function.

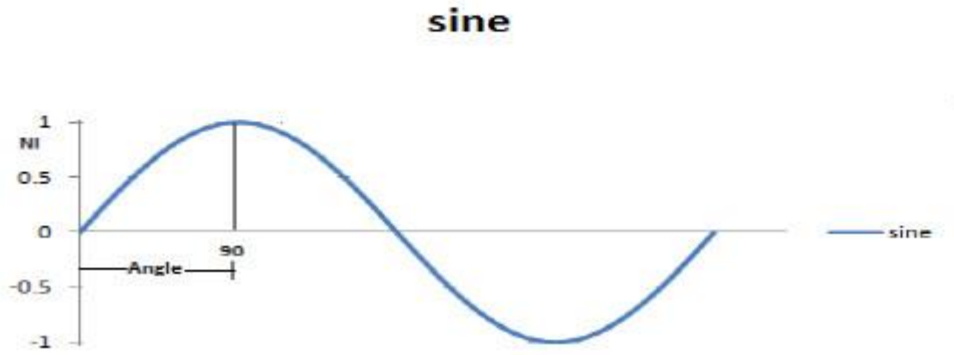


Fig. 3.5 Sine wave of the Normalized image

3.4 Bit Plane Slicing

Bit plane coding is one of the process of lossless image compression technique. A bit plane is a set of bits corresponding to a given bit position in each of the binary numbers in an image. It is used to determine the adequacy of numbers of bits used to quantize each pixel in the image [9].

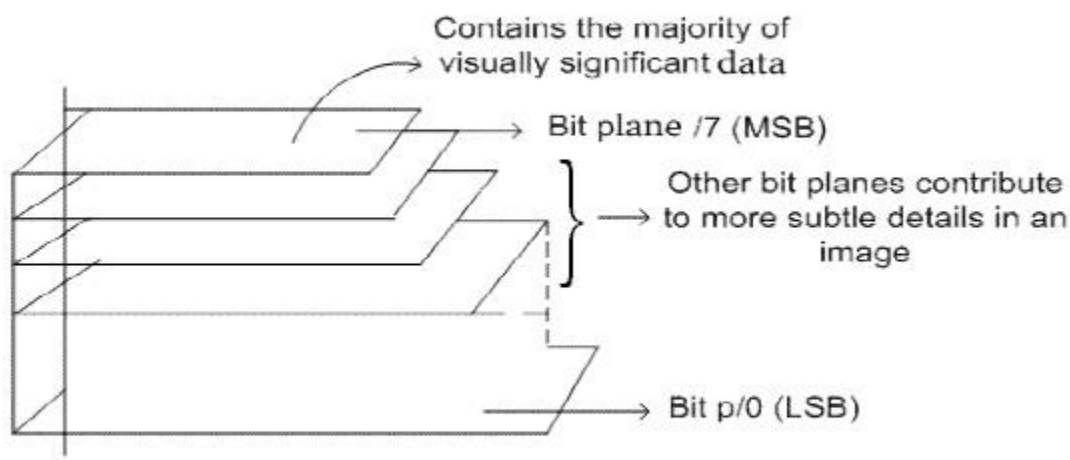


Fig.3.6 Bit Plane slicing for 8 bit image

From figure 3.6, it is seen that instead of highlighting gray level images, it is desired to highlight the contribution made to total image appearance by specific bits. Suppose that each pixel in an image will be represented by 8 bits. Assume that the image is composed of 8, 1-bit planes ranging from bit plane1-0 (LSB) to bit plane 7 (MSB). After getting all separate bit planes from the image then it should compress the bit planes which does not have visually important data.

4. Experimental Results

The mirrored feature points are extracted from the complete set of feature points found out by using the SIFT algorithm. A number of axes are computed from the matching key feature points. Further, the major axes are extracted from the set. This can be done with the help of Hough Transform. Then the image is converted into vector using Zig-Zag mapping. After that the image get compressed by Angular transform which provides the efficient compression when combined with symmetry processed image.

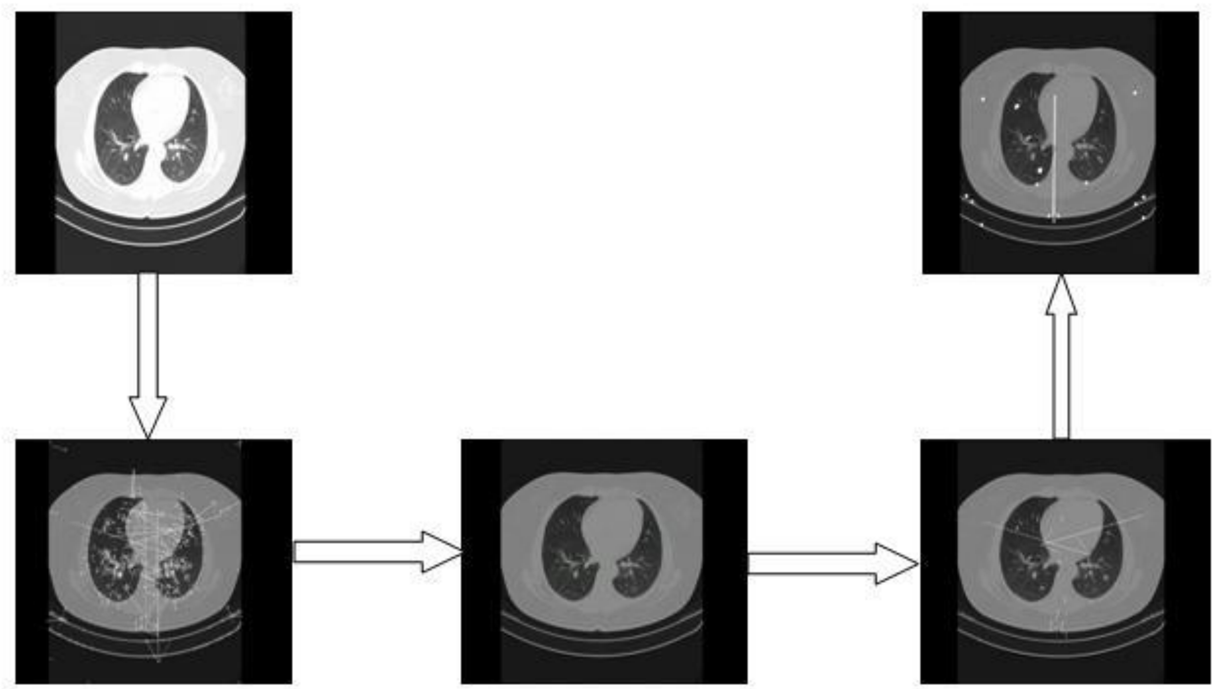


Fig.4.1 Symmetry Processed Image

The algorithm is tested and verified on MRI - Chest, Brain, Abdomen and CT – Brain and Abdomen.

Table.4.1: Compression Ratio Analysis of Existing work

S.No	Image Type	Size of an image (KB)	Compression ratio (CR)			
			Only JPEG-LS	Symmetry + JPEG-LS	Only JPEG-LS 2000	Symmetry + JPEG-LS 2000
1	MRI-Brain	130	0.3846	0.3515	0.3530	0.1416
2	MRI-Chest	563	0.3287	0.1488	0.2704	0.0647
3	CT-Abdomen	520	0.3211	0.2288	0.2519	0.1040
4	CT-Chest	514	0.3287	0.1488	0.2704	0.0647
5	CT-Head	520	0.4980	0.2096	0.4423	0.0934

The above table represents the comparison of symmetry processed images with various types of encoders such as JPEG-LS and JPEG-LS 2000. The following table 2 shows the better results when compared with the table 1.

Table. 4.2 : Comparison of CR on Symmetry Processed Image with other Encoders

S.No	Image Type	Size of an image	Compression ratio (CR)		
			Symmetry + Huffman	Symmetry + Arithmetic	Symmetry + JPEG-LS
1	MRI-Abdomen	1.05MB	0.1503	0.5366	0.2288
2	MRI-Brain	1.05MB	0.3379	1.4475	0.3515
3	MRI-Chest	1.05MB	0.9141	1.0134	0.9563
4	CT-Brain	1.05MB	0.8505	1.1054	0.9730
5	CT-Abdomen	1.05MB	0.9010	1.5417	1.0732

The above table show that the comparison of compression ratio on various types of bio-medical images

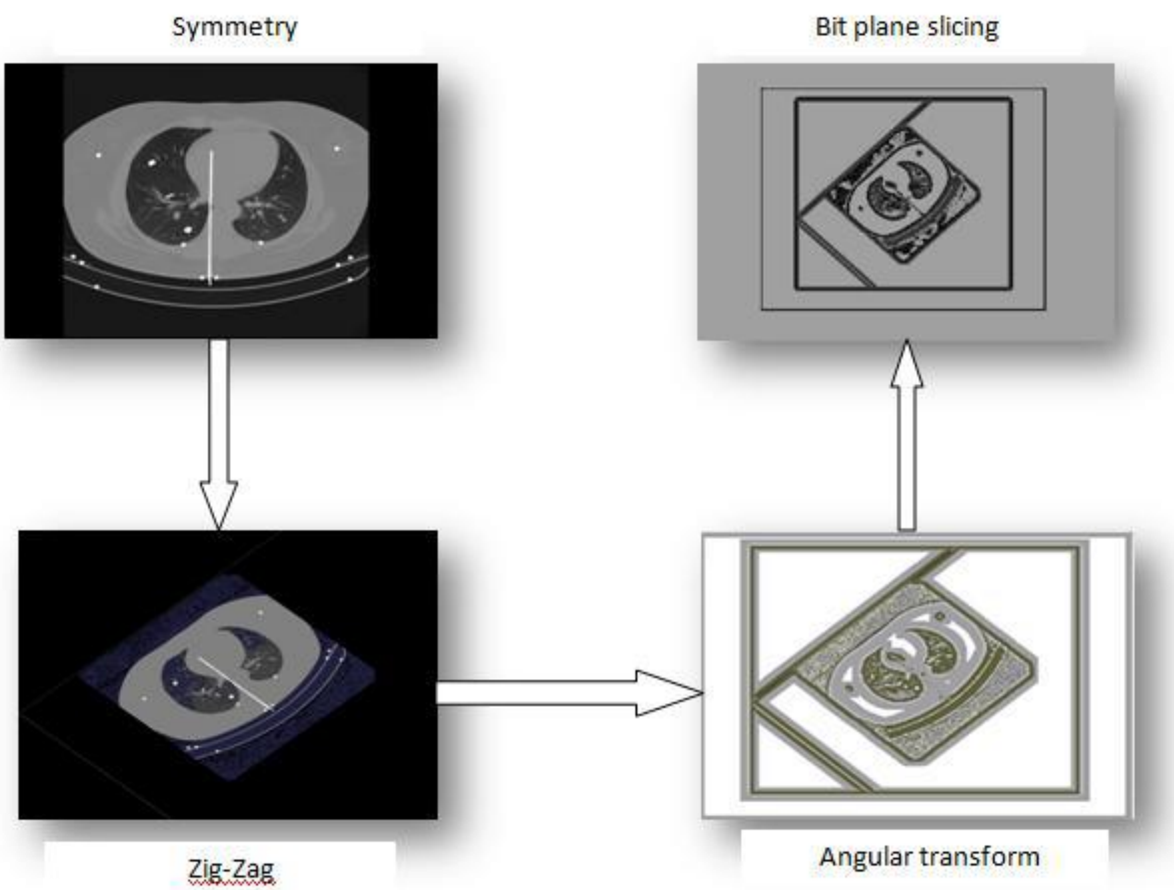
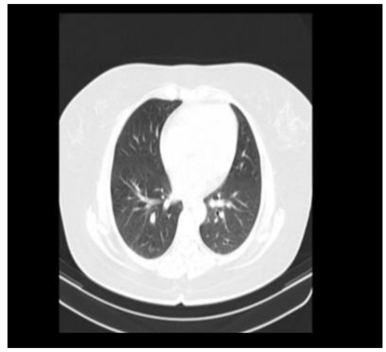


Fig. 4.2 Proposed Work

The figure 4.2 shows the output of bit plane slicing. This can be obtained by separating the bit planes after angular transformation process and eliminate the bit planes which does not having significant information which leads to compression. Decompression can be done by taking reverse process of above methods. In this work it provides better reconstructed image as relevant to original image than Huffman. The following image shows the original and reconstructed image by taking inverse operation.

Original Image



Reconstructed Image

Fig.4.3 Decompression stage

Table 4.3 Performance Analysis of proposed work

Image Type	Parameters	Symmetry + AT and Bit Plane Encoding
MRI-Abdomen	Compression Ratio	0.2974
	Time Elapsed	10s
	MSE	2.875
	PSNR	43.577
MRI-Brain	Compression Ratio	0.2338
	Time Elapsed	11s
	MSE	2.418
	PSNR	44.329
CT-Brain	Compression Ratio	0.3080
	Time Elapsed	12s
	MSE	2.453
	PSNR	44.982

The algorithm is tested and verified on MRI - Brain, Abdomen and CT – Brain and Abdomen. The developed method is used as one of the pre-processing blocks along with standard compression algorithms like Huffman coding, Arithmetic coding, and JPEG-lossless (LS), and the results are presented in Table 4.3

From the above table 5.1, it is clear that for CT, MRI images using symmetry as a pre-processing block, Compression Ratio of traditional Arithmetic and JPEG-LS encoder are given and the Huffman encoder has the better Compression Ratio when compared to other encoders. In previous work it is verified that Angular transform and Bit plane slicing provides the better image compression with less amount of computational complexity. And also provides better image decompression too.

Table.4.3 Comparison of CR on Symmetry Processed Image with other Encoders

Image Type	Parameters	Symmetry +Arithmetic	Symmetry + JPEG-LS	Symmetry + Huffman (Phase I)	Proposed Method
MRI-Abdomen	Compression Ratio	0.5366	0.2288	0.4503	0.2974
	Time Elapsed	38s	30s	20s	10s
MRI-Brain	Compression Ratio	1.4475	0.3515	0.3579	0.2338
	Time Elapsed	40s	29s	19s	11s
MRI-Chest	Compression Ratio	1.0134	0.9563	0.7141	0.5509
	Time Elapsed	45s	33s	21s	13s
CT-Brain	Compression Ratio	1.1054	0.9730	0.5505	0.3080
	Time Elapsed	29s	25s	22s	12s

The table 4.3 describes the symmetry process outputs of various encoders which shows that Symmetry + AT and Bit plane slicing provides better compression ratio than these encoders. So it is proved that Symmetry + AT and Bit plane slicing provides better results (ie., complete lossless compression upto 50%) when compared to Huffman encoder.

Table 4.4 Decompression phase analysis on Symmetry Processed Image with Existing and Proposed work

Image Type	Parameters	Symmetry + Huffman (Phase I)	Proposed Method (Phase II)
MRI-Abdomen	MSE	8.98	2.87
	PSNR	31.28	43.57
MRI-Brain	MSE	8.03	2.41
	PSNR	32.01	44.32
CT-Brain	MSE	7.38	1.97
	PSNR	34.13	45.20

The above table shows that analysis of decompression phase on various symmetry processed images like MRI-Brain, MRI-Abdomen, CT-Brain etc., In decompression phase also the proposed work provides a better results when compared with previous work. Hence it proves that AT and Bit plane coding works better than Huffman coding in terms of both compression ratio and computational complexity.

5.3 Discussion

The results show that the symmetry-based compression approach gives better compression ratios as compared to the standalone Huffman compression method. The technique is completely lossless and hence the diagnostic ability of the image is fully retained. The compression ratios are approximately 11 % enhanced as compared to those achieved when only the encoding technique (AT and Bit plane) is applied. The timing complexity is get reduced when compared to Huffman technique. Thus, higher compression ratios are obtained with less time of processing.

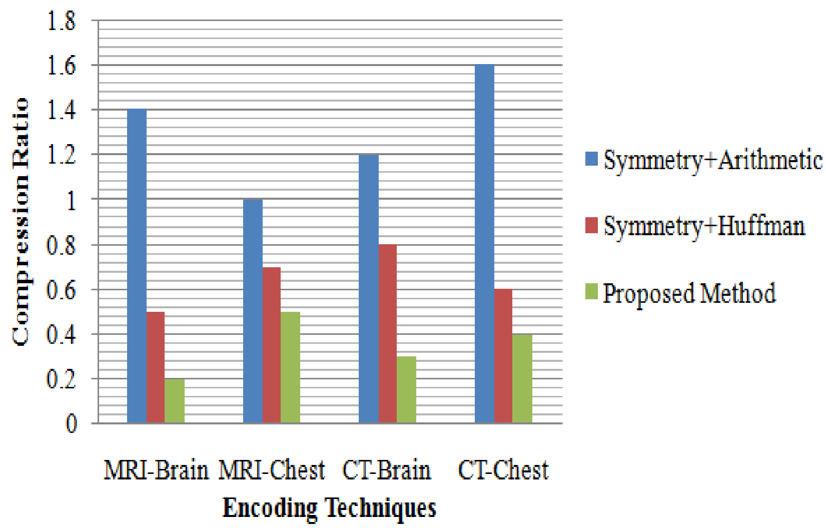


Fig. 5.1 Graphical Representation of comparison on Compression Ratio with Various Encoding Techniques

The graph is plotted between the compression ratio and various encoding techniques. From this it easily observed that proposed work (AT and Bit plane encoder) provides the better results than previous work (Huffman encoder).

6. Conclusion

This approach efficiently compressing an image based on the symmetry redundancy present in the image. The algorithm has been modified in such a way that the symmetry redundancy removal and the encoding scheme both complement each other and thus the entire image is stored in less than 10 % of the memory requirement of the original image. In case of this algorithm, half of the image is compressed directly if it is completely symmetric and due to application of encoding technique further compression is achieved. The more the symmetric element in an image has the higher compression. From the analysis, it shows that proposed work gives better compression and decompression than Huffman technique.

7. Future Enhancement

The symmetry technique achieved greater compression while at the same time not compromising with the data quality. The use of the presented method can also be extended for applications of volumetric medical images.

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