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Secured Lossless Medical Image Compression Based On Adaptive Binary Optimization

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***Abstract**: Image and data compression is of vital importance and has great significance in many practical applications. Large amount of medical image sequences are available in various hospitals and medical organizations, which occupies considerable storage space. Hence to reduce the storage space there is a need for compressing medical images. In this paper we made an analysis of compressing a medical image using a simple but effective technique called adaptive binary optimization (ABO) based on Repetition and correlation coding and proposed an enhanced security technique on compressed data to attain a high security.*
ABO is a process and a system for compressing highly correlated image data. The system comprises of capturing the image, converting into digital form, reshaping the data into matrix form, encoding the repetitions into a bit-plane index and encoding data values for storage, storing the compressed data in memory and retrieving the data for decompression. This technique is simple in implementation and utilizes less memory as compared to other lossless compression technique and added security features make it an efficient lossless technique for medical image compression.
***Keywords**: ABO, Bit-Plane, Data Value Stored, Repetition Coded Compression , Security*

I. Introduction

The trend in medical imaging is increasing toward direct digital image acquisition. Currently, many modalities such as CT(computed tomography), MRI (magnetic resonance imaging), PET (positron emission tomography), SPECT (single-photon emission computed tomography), and DSA (digital subtraction angiography) produce images directly in digital form. It appears that telemedicine and digital image processing will eventually completely replace conventional film (hard copy) imaging in medicine. Important advantages of digital imaging are in support of image transfer and archival, and the possibility for manipulating and enhancing diagnostic information. However, digital image transmission and storage face major challenges due to the size of medical image data sets. For instance each MRI and CT image requires an average of 5 to 12 Mbytes and a single X-ray may require as much as 24 Mbytes. The size has leads to searches for effective image compression methods to reduce the storage requirements and network traffic and improve efficiency.

Lossy compression can achieve high compression ratio, 50:1 or more, but it cannot completely recover the original data. On the other hand, lossless compression can completely recover the original data but this reduces the compression ratio to around 2:1. In medical application, lossless compression has been a requirement because the loss of any diagnostic information is not permitted. In this paper a new lossless and secured medical image compression method called ABO based on RCC is discussed.

II. Lossless Compression

In lossless compression scheme, shown in Fig.1 the reconstructed image, after compression, is numerically identical to the original image. It is used in many applications such as ZIP file format & in UNIX tool g-zip. It is important when the original & the decompressed data be identical.

The goal of lossless image compression is to represent an image signed with the smallest possible number of bits without loss of any information, thereby speeding up transmission and minimizing storage requirement. This reproduces the original image without any quality loss. This is irreversible. This involves two steps.

(i) Modeling-Generates a statistical model for the input data. Statistical modeling algorithm for text include Burrow-wheeler transform, LZ77, LZW and PPM
(ii) Coding-Maps the input data to bit strings. Encoding algorithm to produce bit sequences are Huffman coding and arithmetic coding. These coding are serves as source encoder

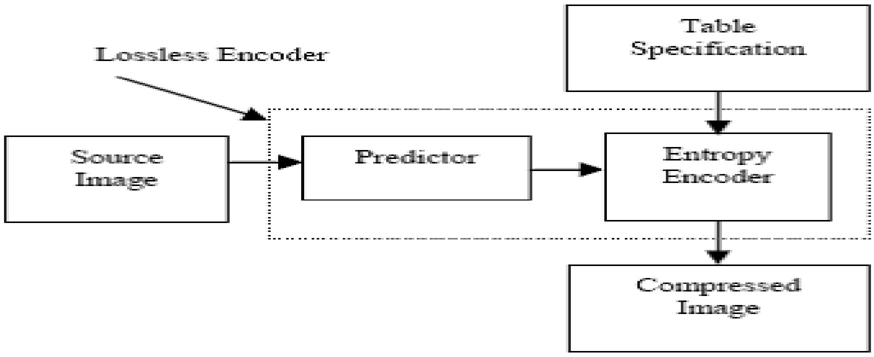


Fig.1. Block diagram for lossless image compression

2.1. Current image compression techniques disadvantages

There are various Image Compression Techniques. Familiar few are jpeg, jpeg-ls, jpeg-2000 and calic.

2.1.1.JPEG

Blockiness results at high image compression ratios. It produces poor image quality when compressing text or images containing sharp edges or lines. It is not suitable for 2 bit black and white images. It is not resolution independent.

2.1.2.JPEG-LS

It does not provide support for scalability, error resilience or any such functionality.

2.1.3.JPEG-2000

Jpeg-2000 do not provide any truly substantial improvement in compression efficiency and are significantly more complex than JPEG, with the exception of JPEG-LS for lossless compression. Complexity involved in JPEG-2000 is more for a fewer enhancement in the compression ratio

2.1.4.CALIC

Although CALIC provides the best performances in lossless compression, it cannot be used for progressive image transmission (it implements a predictive based algorithm that can work only in lossless/nearly-lossless mode). Complexity and computational cost are high.

III. Framework Of ABO

Adaptive Binary Optimization, (ABO) is a lossless image compression algorithm by MatrixView. It uses a patented method to compress the high correlation found in digital content signals and additional compression with standard entropy encoding algorithms such as Huffman coding. ABO is a new way of transforming data – unlike JPEG, JPEG2000, JPEGLS, GIF, TIFF, PNG, MPEG1, MPEG2, MPEG4 or MP3. While traditional systems depend on complex transforms and the elimination of data to achieve compression, ABO does not.

Driven by a unique, breakthrough process called Repetition and Correlation Coding (RCC), ABO exploits the repetition and correlation found in data. This results in a revolutionary data transformation and establishes a strong foundation for further modeling and source coding of data. The effects of this bottom-up transformation can be felt strongly at every level of the network. The results of this strikingly simple and powerful process are amazing ABO just transforms the way in which data is stored, transmitted, retrieved and applied – with highest compressibility and without loss of data and integrity.

3.1. Rcc construction

RCC is a visually lossless compression technique and is also pixel-to pixel lossless with zero means square error (MSE). RCC achieves a very impressive level of compression based on coding repetitions. RCC with encryption support is a modification of the generic RCC method. The generic RCC method forms a framework that is used by the encryption modules. Data-scrambling mechanisms in RCC translates compressed data into a secret code. To achieve an effective data security system without any loss of data or time, RCC encryption converts the compressed data and encodes into a form that is incomprehensible by means of a key, so that it can be reconverted only by an authorized recipient holding the matching key derives its security from the inherent randomness in shuffled image data. To perfectly reconstruct the image, RCC Store and Bit plane matrices are made available to the reconstruction algorithm.

3.1.1. Bit plane

Bit plane indexing creates a redundant array of only zeros and ones. This improves the compression ratio without any loss or increase in the data set. In the bit plane indexing process, the raw original image data is decomposed to various types of bit planes. For example, these include horizontal, vertical or a combination of both, in an integer-to-integer matrix. A bit plane of zeros and ones is obtained along with the index of the image. The original image can be reconstructed perfectly lossless with the index and the bit plane. The choice of which bit plane to use is dependent on the application or final product. In repetition coded compression (rcc) each element is compared with the previous element. If both of them are equal then a value of "1" is stored in a bit-plane. Otherwise a value of '0' is stored in the bit-plane. Only the difference value is stored in a matrix, instead of storing all the repeating values.

3.1.2. Data value stored

The data sequence with only bit plane value 0 is stored in data value thus discard the redundant value. It is shown in Fig.2

Data Sequence:	10	10	10	9	8	8	9	10	10
Bit Plane:	0	1	1	0	0	1	0	0	1
Value Stored:	10			9	8		9	10	

Fig.2. Data value construction

3.1.3. RCC Horizontal

In RCC horizontal transformation only one bit-plane is used to code the repetition of values. That is, the bit-plane is in the horizontal direction only. In the RCC horizontal transformation, adjacent data elements, for example, pixels in the case of images, are scanned in raster order (from left to right and then from top to bottom). If both adjacent data elements are equal, then a value of "1" is stored in the matrix or bit plane. Otherwise if they are not equal, a value of "0" is stored in the bit plane matrix. Only this different value is stored in the bit plane matrix instead of storing all the repeating values.

HORIZONTAL RCC

250	**250**	**250**	**100**	**100**	**100**
250	**250**	**250**	**100**	**100**	**100**
20	**20**	**20**	**250**	**250**	**250**
20	**20**	**20**	**250**	**250**	**250**
150	**150**	**150**	**20**	**20**	**20**
150	**150**	**150**	**20**	**20**	**20**

Rules for adjacent pixels
If same value ,bit plane='1'
If different value, bit plane='0'

Final value stored

250	100	250	100
20	250	20	250
150	20	150	20

BIT PLANE

0	**1**	**1**	**0**	**1**	**1**
0	**1**	**1**	**0**	**1**	**1**
0	**1**	**1**	**0**	**1**	**1**
0	**1**	**1**	**0**	**1**	**1**
0	**1**	**1**	**0**	**1**	**1**
0	**1**	**1**	**0**	**1**	**1**

Fig.3. Horizontal RCC manipulation

3.1.4. RCC Vertical

RCC vertical transformation is similar to the RCC horizontal transformation described except that image data is compared in a non-raster order. This transformation still preserves the lossless nature of the transform. A vertical variant is similar to the horizontal variant transformation described except that image data is compared in a non-raster order. This transformation still of "1" is stored in the matrix or bit plane. Otherwise if they are not equal, a value of "0" is stored in the bit plane matrix. Only this different value is stored in the bit plane matrix instead of storing all the repeating value

VERTICALRCC

250	**250**	**250**	**100**	**100**	**100**
250	**250**	**250**	**100**	**100**	**100**
20	**20**	**20**	**250**	**250**	**250**
20	**20**	**20**	**250**	**250**	**250**
150	**150**	**150**	**20**	**20**	**20**
150	**150**	**150**	**20**	**20**	**20**

values stored

250 100 250 100
20 250 20 250
150 20 150 20

BIT PLANE

0	**0**	**0**	**0**	**0**	**0**
1	**1**	**1**	**1**	**1**	**1**
0	**0**	**0**	**0**	**0**	**0**
1	**1**	**1**	**1**	**1**	**1**
0	**0**	**0**	**0**	**0**	**0**
1	**1**	**1**	**1**	**1**	**1**

Rules for adjacent pixels
If same value ,bit plane='1'
If different value, bit plane='0'

Fig.4.Vertical RCC manipulation

IV. Proposed System

Security is a significant issue in image compression. Applications such as video-on-demand, pay-per-view and medical imagery require data protection in addition to compression. For example, in a medical imaging application, modern healthcare standards like HI7 and DICOM make it compulsory to store patient details for up to five years. It is necessary to compress images to save storage space. Also, it is necessary to ensure that the transmission and storage of these images are secure to maintain the nature of the patient details.

Encryption is a secure and trusted method for storing highly sensitive information privately. Encryption is a reversible process by which bits of data are mathematically scrambled and unscrambled using a password key. Existing open image compression standards are not designed allow the addition of an encryption layer. In this proposed system the final values stored is encrypted using a pivotal value as a key to encrypt the reduced final value stored. This process will add a security to the compressed image.

Final values stored

250 100 20
150 20

Encrypted final value stored

1 0 0
1 0

Fig.5 Encrypted value stored

V. Comparison And Discussion

The three sample of MRI images are taken and tested on ABO, JBIG1 and CCITT G4.The image compression ratio achieved by the ABO method is high as compared to the compression ratio obtained by the JBIG1 and CCITT G4 standard. Thus ABO proves to be a efficient lossless compression method as compared to other prevailing lossless compression standard such as JBIG1 and CCITT G4 standard

The compression ratio is defined as follows:

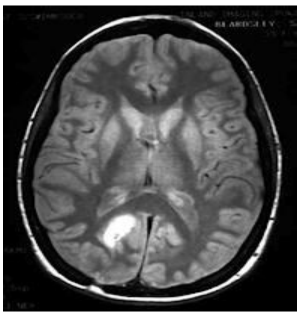
$Cr = N1/N2$

Where,

N1 is the data of the actual image

N2 is the data of compressed image

Original Image



Original file size= 188 kb

File size after RCC =44 kb

Fig. 6. Compressed image

Table 1: Compression ratio of ABO, JBIG1 and CCITT G4

Sample Average Compression Ratio				
Image	Sample Size	ABO	JBIG1	CCITT G4
Sample 1	10	13.45	13.40	9.00
Sample 2	10	16.50	16.45	12.02
sample 3	12	20.59	20.49	13.56
Overall		22.45	16.39	11.35

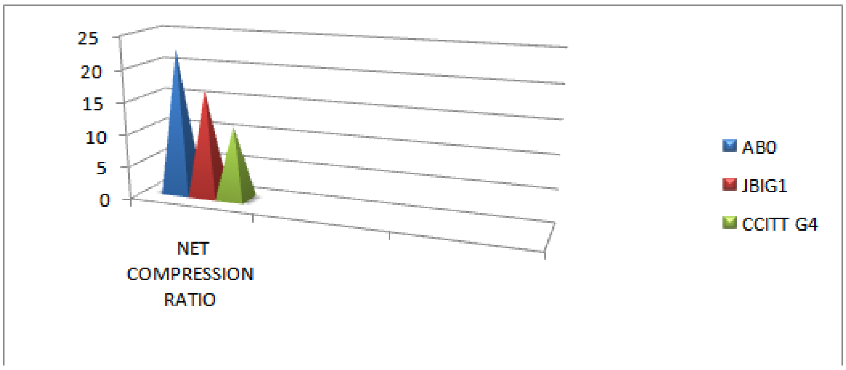


Fig.7. Comparison of ABO, JBIG1 & CCITTG4

VI. Conclusion

The adoptive binary optimization based on repetition and correlation coding proves to be an efficient lossless compression method then other lossless standards without a considerable loss in the image quality adding the encryption layer to this compression technology will strengthen and benefit the telemedicine and various other industries. I t achieve 32% of compression in a 8-bit data sequence.

The application of repetition Coded Compression to the entire image is capable of compressing its size to 44,000 bits from the original 188,000 bitts. The total memory required for the 36-pixel region of an image is generally 188 bits. After applying repetition Coded Compression the memory required was 44bits. This proves a great amount of compression achieved. It is tested on grayscale images but also suitable for rgb images. In future we need much concentration on improving the security of compressed medical image and other valuable data and achieving good compression ratio in order to save the transmission, processing and storage cost.

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