HYBRID METHOD TO COMPRESS SLICES OF 3D MEDICAL IMAGES

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ABSTRACT

Now days 3D medical images like MRI, CT are integral part of standard health care. These images are rich in volume and provide important diagnostic information, so there should be some proper method to compress these images. The method proposed in this paper is symmetry based technique for lossless compression of 3D medical image data. The proposed method uses anatomic symmetries present in structures of medical images to reduce energy of sub-bands. It uses Run Length Encoder and Huffman coder, which encodes the residual data generated after prediction to provide resolution and quality scalability. The technique can be compared with other compression techniques like RLE and Huffman. It gives an average improvement in compression ratios.

Keywords: symmetry; volumetric images; lossless compression; RLE; Huffman.

1. INTRODUCTION

Telemedicine is the use of electronic information to communicate technologies to provide and support healthcare when distance separates the participants. It needs the fast and error free communication of medical images to their destination to perform e-consultancy between various specialists to agree upon the correct diagnosis of patient [1]. As Telemedicine deals with diagnosis of medical data there is no scope of information loss and delay in transmission. If we are dealing with medical images they require large storage space, and large transmission time [2].

In recent years 3D medical images like Magnetic Resonance Imaging (MRI), Computed Tomography (CT) are considered as important part of standard health care. As the amount of 3D medical images generated increases, the storage, management, and access to these large repositories is becoming increasingly complex. Because this data provides
important diagnostic information, care must be taken in compressing it. Compression methods are classified into lossless and lossy methods. In the medical image compression lossy schemes are generally not used to avoid possible loss of useful clinical information which may influence diagnosis [3]. As 3D medical images are large in volume and consist of valuable data, lossless compression is usually the standard in medical imaging to avoid any negative effects on image quality and diagnostic capabilities. The most desirable properties of any compression method for 3D medical images include: high lossless compression ratios, resolution scalability, and quality scalability. All of we know that human body has vertical symmetry, which means one half part of body is approximate replica of other half part. In this paper we are going to make use of this symmetry of human anatomy to achieve maximum compression of medical images without any losses. There are some examples of symmetric human body organs as axial view of brain, pupil, labia, cervical, lumbar, chest, thorax, larynx, lungs, etc.

In this paper, we propose a scalable lossless compression method for 3D medical images that attains the three desired properties listed above and uses the symmetrical characteristics of the data to achieve a higher lossless compression ratio. The method is well described in further discussion.

2. BLOCK DIAGRAM

![Block diagram of proposed method](image)

The input images are 3D medical images which are output of MRI of different human body organs. These images are having axial symmetry. The very first step is to check whether the input image is appropriately positioned. That means we have to check that image is neither rotated nor shifted. If this is so then first step is to convert it in proper form. Next block performs symmetry detection. After finding axis of symmetry the image is divided into two parts as left part and right part. These two parts are separated and subtracted from each other to get residual data. This residual data is encoded using RLE coding and Huffman coding to get compressed bit stream.

2.2. DETECTING AXIS OF SYMMETRY

Detecting axis of symmetry is an important issue. Several techniques have been proposed for detecting symmetry. One of simple and efficient of them is by finding the centroid of the image. We have first found out the centroid and the edges of the images using different MATLAB functions. After finding the axis of symmetry of the image, we assume that the image is almost symmetrical. The assumption is based on the fact that we are mainly using human medical images and that the human body is said to be largely symmetrical.

2.3. RESIDUAL DATA

Due to the inherent symmetry of the human anatomy, cross-sections of the ROIs depicted in slices of 3D medical images are typically symmetrical [5]. There are two types of
symmetries, global symmetry and local symmetry. Global symmetry refers to the symmetry of the whole sub-band that is nothing but a main axis of symmetry, while local symmetry refers to the symmetry of a small region within the sub-band as defined by a local axis of symmetry [6]. Here in this method we have used only the concept of Global symmetry to avoid complexity of local symmetry.

After getting centroid of the image next step is to plot axis of symmetry. Along the axis of symmetry the image is divided into two parts. By doing this we can partition image in to two areas of equal size as left part (LHi-L) and right part (LHi-R) [1]. We calculated the difference between the left part and right part that generates the residual data with less energy than the original data.

So we can consider following example of axial view of brain [1]. The figure 4 shown below gives high pass sub-band (LH) of an MRI slice. It is easy to find out main vertical axis of symmetry which is centered in the sub-band. So we can make partition of sub-band into areas along with axis of symmetry.

![Figure 4](https://via.placeholder.com/150)

**Figure 4:** Horizontal high pass sub-band of slice of an MRI volume of the axial view of human head

Let’s denote area to the left of the axis as LHi-L and the area to the right as LHi-R. If LHi-L is to be flipped along the axis of symmetry, it would be expected to provide a good approximation to LHi-R and can therefore be used to predict LHi-R. So this data i.e. residual data obtained from right part and flipped left part and complete right part is used as input to the encoder.

### 2.4. Encoding Residual Data

Run-length encoding (RLE) is a very simple form of data compression in which runs of data are stored as a single data value and count, rather than as the original run [12]. RLE works by reducing the physical size of a repeating string of characters. The main advantage of RLE is that, it performs lossless compression of data. The other encoder we are using is Huffman encoder. Huffman codes are variable-length codes and are optimum for a source with a given probability model. In Huffman coding, more probable symbols are assigned shorter codewords and less probable symbols are assigned longer codewords to find the code. So at the output of this block we are getting data which is compressed bit stream. Now this data can be easily stored and transmitted.
2.5. RECONSTRUCTION OF ORIGINAL IMAGE.

The output of the encoder is compressed bit stream which is to be reconstructed at the decoder. At the receiver side we have to reconstruct image by following inverse of the algorithm which is used for encoding. So we have to first decode the compressed bit stream by run length decoder or Huffman decoder whichever is used to encode the data. This data is then converted to image. The last step is to add the residual part in that image which will give the image same as the input image. Hence the technique is completely lossless.

3. RESULTS

Part I:
The results shown in table 1 are achieved by performing simple subtraction of 3D medical images.

<table>
<thead>
<tr>
<th>Name</th>
<th>Original Image</th>
<th>Subtracted Image</th>
<th>Size of image after RLE</th>
<th>Size of decoded image</th>
</tr>
</thead>
<tbody>
<tr>
<td>A83GL6</td>
<td>Entropy</td>
<td>Size (kb)</td>
<td>Difference</td>
<td>Entropy</td>
</tr>
<tr>
<td>G0</td>
<td>5.2828</td>
<td>530</td>
<td>1</td>
<td>5.1701</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A83GL6</td>
<td>5.4097</td>
<td>652</td>
<td>1-2</td>
<td>1.9645</td>
</tr>
<tr>
<td>G2</td>
<td></td>
<td>2D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A83GL6</td>
<td>5.3654</td>
<td>652</td>
<td>2-3</td>
<td>1.7083</td>
</tr>
<tr>
<td>G4</td>
<td></td>
<td>2D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A83GL6</td>
<td>5.4397</td>
<td>647</td>
<td>3-4</td>
<td>2.7519</td>
</tr>
<tr>
<td>G6</td>
<td></td>
<td>2D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A83GL6</td>
<td>5.3867</td>
<td>620</td>
<td>4-5</td>
<td>3.1915</td>
</tr>
<tr>
<td>G8</td>
<td></td>
<td>2D</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

First of all we convert 3D image into 2D image. The first image is as the reference for reconstruction so it is stored as it is. Second image is now subtracted from first image and only residual part is stored as second image instead of complete second image. Then third image is subtracted from second image and only residual part is stored as third image just like did for second image. And hence so on. So by doing this we can achieve good compression. But this method results in some minor losses which we cannot afford while working with medical images. The same idea we used in our algorithm by making use of anatomic symmetry.

Part II:
The results shown in the table 2 gives comparison between the RLE, Huffman and proposed method. Eight data sets of MRI images of different body organs are taken. The images are compressed first by the proposed method of symmetry and then compression ratio is calculated. Then images are compressed by only RLE and also by Huffman, again compression ratio is calculated. The table shows that our proposed method gives good results over RLE and Huffman both.
Table 2: Comparison of compression ratios of MRI Images from database

<table>
<thead>
<tr>
<th>Original Image</th>
<th>Compression Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Only RLE</td>
</tr>
<tr>
<td>(a) Brain</td>
<td>3.95:1</td>
</tr>
<tr>
<td>(b) Brain</td>
<td>4.47:1</td>
</tr>
<tr>
<td>(c) L Spine General</td>
<td>2.96:1</td>
</tr>
<tr>
<td>(d) L Spine</td>
<td>5.52:1</td>
</tr>
<tr>
<td>(e) C Spine General</td>
<td>1.52:1</td>
</tr>
<tr>
<td>(f) T Spine General</td>
<td>3.34:1</td>
</tr>
<tr>
<td>(g) Pelvis &amp; Hip General</td>
<td>2.20:1</td>
</tr>
<tr>
<td>(h) Abdomen</td>
<td>3.36:1</td>
</tr>
</tbody>
</table>

The input images shown in figure 5 to which the above coding algorithm is applied for to generate compressed bit stream. Then decompression algorithm is applied to get the original image back from the compressed data, which is shown in the figure 6. The output image is the decompressed image i.e. from the figure 6 it is clear that the output image of the algorithm is exactly same as the input image. So proposed method is exactly lossless.

![Image 1](image1.png) ![Image 2](image2.png)

**Figure 5:** Original Medical Images

![Image 1](image3.png) ![Image 2](image4.png)

**Figure 6:** Reconstructed Images obtained after applying proposed algorithm
4. FUTURE WORK

In this paper we have got comparative results for RLE, Huffman and proposed method. Our next approach is to use several different encoding techniques to compress and reconstruct medical images without any loss. The comparative study will help to choose better method. We will try to improve compression ratio more.

5. CONCLUSION

In this paper, an image compression algorithm that utilizes anatomic symmetries present in medical images is proposed. The algorithm first divides image slice into two parts along the axis of symmetry. The residual part is found out by comparing two parts, which is to be encoded using Huffman or RLE. This gives compressed bit stream at the output of encoder which is decoded at receiver to reconstruct the image.

This paper focused on the evaluation of several commonly used algorithms for lossless compression. The proposed method is a 3D scalable lossless compression of medical image data. So our aim is to increase compression ratio with reducing complexity while achieving compression.

6. REFERENCES


