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DWT based Compression of X-Ray Images using Fuzzy C - Means

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Abstract

People, Hospitals and many other organizations manage to store a large amount of files inside their storage devices. Once the storage reaches its limit then the organizations try to minimize the files size by using different compression techniques. In this paper, we focus on lossless image compression for DICOM images using clustering approach. Cluster of data point is formed by Fuzzy C-mean clustering approach. An automatic threshold is selected by this clustering approach and the data point whose pixel intensity is greater than threshold is grouped into one cluster and the data point whose pixel intensity is less than threshold is grouped into another cluster. Hence we obtain region of interest (ROI) and Non-region of interest (N-ROI). Discrete wavelet transform (DWT) is used to compress the image and inverse DWT is used to regenerate the image.

Keywords: *Compression, Lossless, DICOM Images, ROI, N-ROI, DWT*

INTRODUCTION

An image is an object of scientific result that represents or record the visual perception. To store large amount of images for the organizations is a tedious task as it requires large storage space. So to reduce the storage space of images, compressions of images are necessary. Compression should be done in such a way that it reduces the size of image without degrading the quality of image to an un-acceptable limit. .

The compression technique is classified into two kinds, lossy and lossless. In lossy image compression, some information is lost at the time of compression. It is also known as irreversible compression. In lossless compression, information is not lost and it keeps the same information as the original image. It is also known as bit-preserving or reversible compression.

There are many existing methods for the lossless and lossy compressions are available. Chroma subsampling, transform coding, wavelet transform, fractal compression are some of the method for lossy compression. Run length encoding, K-mean cluster, Differential pulse code modulation, Predictive coding, Entropy coding, Chain code, DWT are some of the example of lossless image compression. In this paper, we are using fuzzy c means cluster compression algorithm technique for different Digital Imaging and Communication in Medicine(DICOM) such as X-ray, Computed tomography scan(CT scan).

Fuzzy c-mean cluster algorithm is an unsupervised that detects cluster automatically and group these cluster of data based on the threshold value. The data point whose intensity value is greater than threshold is grouped as one cluster and less than threshold is grouped in another cluster.

LITERATURE SURVEY

Agus Dwi Suarjaya [1] has proposed a new algorithm for data compression optimization which make use of J-bit encoding algorithm. The J-bit algorithm is applied on each bit of data in the file to reduce the size without losing any

information after decoding. This algorithm also makes use of other compression algorithm to improve the compression ratio. This algorithm divides the input data into two parts, first part include nonzero byte and 2nd part include the bit value which specifies the position of zero and non- zero byte.

Shaou-Gang Miaou *et al.* [2] has published A Lossless Compression Method for Medical Image Sequences Using JPEG-LS and Inter-frame Coding. JPEG-LS is a lossless compression algorithm but is best for only a single picture and cannot be applied among the picture. So they have used the JPEG-LS and Inter-frame coding algorithm together to overcome the limitation of JPEG-LS algorithm. By using both the algorithm together it achieves 13.3% to 26.3% more compression. Altogether it compresses 77.5% to 86.5% of original image without losing the original information.

Hao Wu *et al.* [3] has proposed Lossless compression of JPEG photo collection. This proposed method removes inter/intra repetition of message in spatial domain. It uses hybrid inequality compensation technique to obtain global and local correlation for images in spatial domain. In frequency domain, the redundancy of adjusted signal and the desired image is reduced. This method achieves more than 31% bit saving.

Saurin s. Parikh *et al.* [4] has proposed high bit-depth medical image compression using HEVC. JPEG-2000 is most commonly used method for medical image compression but it is not appropriate for 3-D image and image series. The compression technique used is high efficiency video calling (HEVC) which is more efficient compared to JPEG-2000. HEVC can support image compression for all kind of medical images.

METHODOLOGY

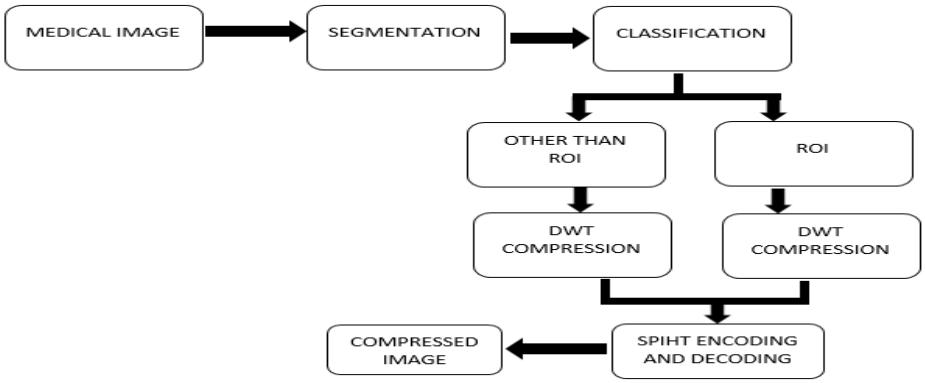


Figure 1: *Block Diagram of Methodology.*

The different kinds of medical image like X-Ray image, computed tomography scan (CT scan) is taken as an input in digital image and communication in medicine(DICOM) format and then it is partitioned into multiple segment for the better analysis. Further the image is classified into region of interest (ROI) and non-region of interest (N-ROI).
The purpose of classification of medical image into two types is to get highest degree of compression. In medical image such as X-Ray image, we are more concerned to the injury portion of the image and rest of the portion of image is not having a great amount of concern. So, the concerned part of the image is classified as region of interest and rest part of the image is classified as non-region of interest. After classification discrete wavelet transformation compression is applied to the ROI which compresses it

lossless and N-ROI is also compressed with DWT compression technique in lossy form to get higher degree of compression. Image statistical characteristics are used as key features for Fuzzy C-mean clustering [5]. Both the compressed ROI and N-ROI part of the image is encoded and transmitted from the sender part and is decoded at the receiver part and then both the compressed ROI and N-ROI is joined to get the whole compressed image at the receiver part.

In this paper, Fuzzy C-means clustering algorithm is used. The algorithm works by calculating the distance between data point and center of the cluster. The numbers of data point clustered in a cluster depend on the number of data point near to the center of the cluster. The clustering of data point is done by minimization function as

$$J_m=\sum_{i=1}^{N}\sum_{j=1}^{C} u_{ij}^{m}\left\|x_i - c_j\right\|^2 , 1 \le m < \infty$$

Where,
m - real number greater than 1
u_{ij} – membership degree of x_i in cluster j
c_j - center of cluster
||*|| -similarity of measured data and center

The clustering of data point is done by the iterative optimization of membership u_{ij} and center c_j by

$$u_{ij}=\left(\frac{1}{\sum_{k=1}^{c}(||x_i-c_j||/||x_i-c_k||)^{\frac{2}{m-1}}}\right)$$

$$c_j=\left(\sum_{i=1}^{N} u_{ij}^{m} * x_i\right)/\left(\sum_{i=1}^{N} u_{ij}^{m}\right)$$

DISCRETE WAVELET TRANSFORMATION

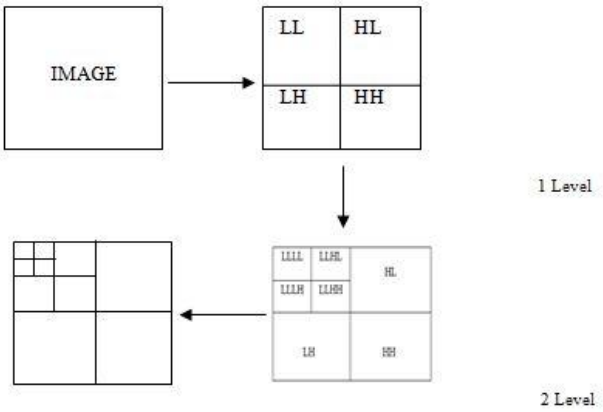


Figure 2: *Different Levels of DWT [6].*

Discrete wavelet transform is a compression technique in which data point is discretely sampled. The benefit of discrete wavelet transform as compared to Fourier transform is that of its temporal resolution i.e. it can measure both frequency and location information.

There are two types of discrete wavelet transform lossless DWT and lossy DWT. In lossless, compressed image is digitally identical to original image and achieves a small amount of compression. In lossy, the redundant signal is discarded and hence the compressed output is changed from the input original image and achieves a great amount of compression compared to the lossless compression.
Noise is removed by using the wavelets in two dimensional signals like digital images. First of all the wavelet type is selected and N level of decomposition. In this paper we have selected 3.5 semi orthogonal wavelets with a level N of 10. The semi orthogonal wavelets are mainly used in processing of image to determine and filter out white Gaussian noise, because of the larger contrast of nearby pixel intensity values.

The threshold value for the level 1 to N is calculated after the decomposition of image file. This threshold value is selected

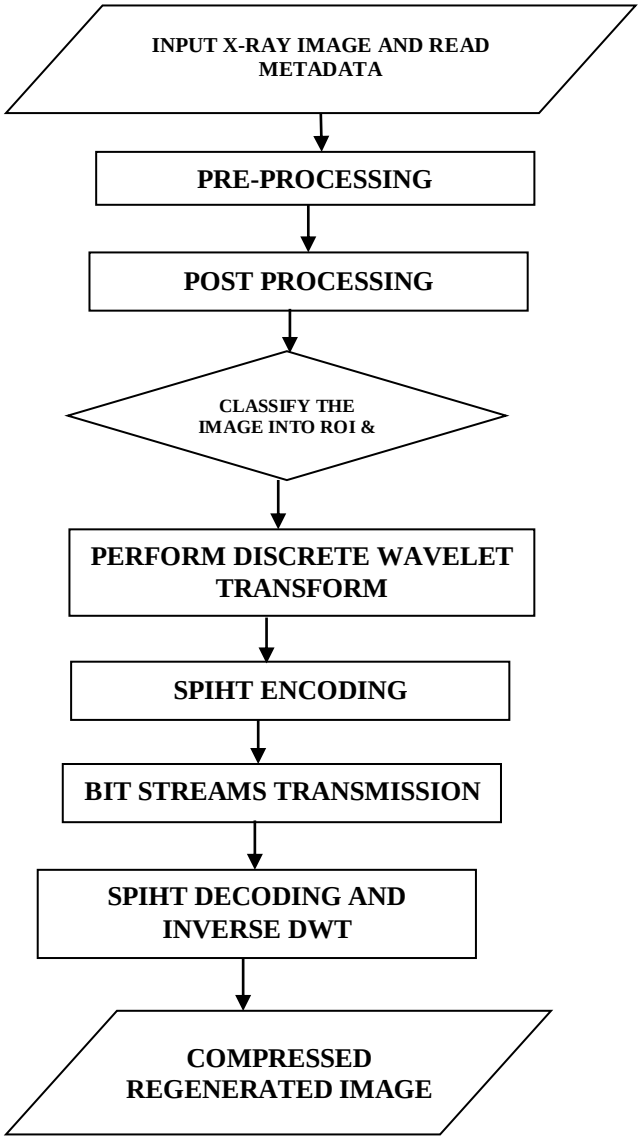
by using the Fuzzy C-mean clustering approach. For N=10 levels, the individual threshold is calculated. Based on these threshold values the clusters are formed. The data point which greater than these threshold is grouped into one cluster and the data point which is less than these threshold is grouped into another cluster.

In the end at the receiver part inverse discrete wavelet transform is applied and image is reconstructed which is the combination of compressed ROI part of image and the compressed N-ROI part of the image from which noise is removed.

ALGORITHM

1. Read input image from database and obtain dimensions and read metadata to a variable.
2. Apply fuzzy c- means clustering to form clusters automatically.
3. Apply threshold to select region of interest and separate out region of interest (ROI) and non - region of interest.
4. Apply discrete wavelet transform for ROI and non - ROI to compress.
5. Apply SPIHT Encoding and transmit bit streams.
6. Bit streams are received and decoding is performed.
7. Inverse DWT is applied to get regenerated compressed Image.
8. Write the metadata to the regenerated compressed image.

FLOW CHART OF ALGORITHM



RESULT AND DISCUSSION

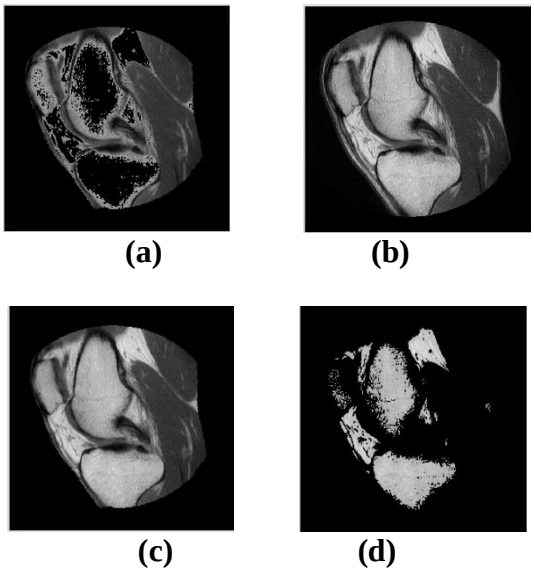


Figure 3: a) *Original X-ray Image of Knee* ***b)*** *ROI Image* ***c)*** *Non- ROI Image* ***d)*** *Compressed Regenerated Image*

A medical X-Ray image of knee is taken and we have applied our proposed method (fuzzy c means clustering and DWT) from which we got ROI and non- ROI images based upon intensity of bone pixels and then clustered into two parts which is then processed and encoded with SPIHT algorithm with results as bit streams and can be transmitted and then decoded at the other end and performed inverse operations to get Compressed Regenerated Image and the compression ratio of above image results to 64%.

MetaData Details of Image:
Patient Details: Alok Kumar
Patient Age: 42
Patient Sex: Male
Part of Body: Knee
Source of Image: Tantia Hospitals

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