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Low-Complexity, Lossless Volumetric Medical Image Compression with PPM-5& Linear Prediction

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ABSTRACT: Several of today's imaging techniques such as CT scan, MRI produces three dimensional data sets obtained by generating multiple slices in a single examination, with each slice representing a different cross section of the body part being imaged.These 3-D volumetric medical images are an important source of digital data that need lossless compression to be stored or transmitted. Several improvements have been made in lossless image compression field. These methods can be roughly divided into single pass & multiple pass techniques. Proposed system uses a low complexity, lossless, compression algorithm for the compression of 3-D volumetric medical images that exploits the three-dimensional nature of the data by using 3-D linear prediction.

KEYWORDS: 3D Volumetric Images, Slices, Linear Prediction, Low complexity, Lossless Compression.

I. Introduction

An image is essentially a 2-D signal processed by the human visual system. The signals representing images are usually in analog form. However, for processing, storage and transmission by computer applications, they are converted from analog to digital form. A digital image is basically a 2-Dimensional array of pixels. Compression techniques are applied on different image present in media. The best quality of reconstructed image at a given bit-rate (or compression rate) is the main goal of image compression codec. Peak signal-to-noise ratio is used to measure quality of a compression method.

Fundamental challenge today is to provide the user with system which will compress image in given hardware & software limitations while maintaining image integrity. Until now main obstacle in communicating large unstructured image was limitations on bandwidth & computer resources. Proposed system will enable the user to communicate images easily with minimum computer usage with given computer & hardware availability.

II. Related work

Proposed in [1] LOCO-I (LOw COmplexity LOssless COmpression for Images) is the algorithm at the principal of the new ISO/ITU standard for lossless and near-lossless compression of images, JPEG-LS.The state-of-the-art lossless image compression scheme consists of three componentsas Predication step, determination of context&a probabilistic model for the prediction residual. In [2] author provides an encoding/decoding for lossless compression of digital pattern of all types. Both encoding/decoding techniques are suitable for sequential & progressive transmission. The system is symmetric viz the encoder& decoder have same time & space complexity. In[3] & [4] author used wavelet transform as an instrument for multiresolution analysis. In transform coding the image is projected onto basis of functionand the resultant transform coefficients are encoded. The wavelet transform is extended down to multiple dimensions by the use of separable filters. Each dimension is filtered & sampled separately.

In [5] author used an extension of symmetric 2D SPIHT tree structure. The algorithm is based on the tree-based coders which tend to give better performance when tree depth is long and the statistical distribution of magnitudes of wavelet coefficients is uneven between the intra-slice and inter-slice directions. Main idea of Sungdae Cho Donyon Kim, & William Pearlman is that this tree structure is to make the trees longer, since that increases the probability of a coefficient value being zero as we move from root to leaves. In [6] ALPC is an algorithm based on adaptive linear prediction and consists of two main steps: pixel prediction and entropy coding of the prediction error. An input image is

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encoded in a single pass, by processing its pixels in raster-scan order (proceeding from top to bottom and from left to right). The luminosity of each pixel, PIX(x, y), is predicted by a weighted sum of its neighbor's (or context). Pixels are individually encoded by representing the prediction error ERR ( ), the difference between the pixel being encoded, PIX ( ) and its predicted luminosity.
In [7] author proposed an algorithm as MILC which takes slices of image as input. It uses inter-slice-predictive model to predict the value of next pixel fallowed by error coding. Each codec steps implements different version of PPM to code the mapped prediction errors.

III. PROPOSED ALGORITHM

A. *FLOW OF THE PROPOSED ALGORITHM:*

Aim of the proposed algorithm is to minimise space requirement along with lossless form of compression so the reconstructed image does not compromises medical image which may lead to incorrect diagnosis or wrong treatment. The proposed algorithm's flow can be given by fallowing steps,Step 1: Take Input Image

Step 2: Initialize Voxels
Step 3: Create affine map
Step 4: Get & shift Intensity of each Pixel
Step 6: Create Slices
Step 7: Apply transformation
Step 8: Store the image in PNG format with ARGB color space
Step 9: End.

B. *DESCRIPTION OF PROPOSED ALGORITHM:*

- Initializing voxels:A voxel represents a single data point on a three-dimensional grid. This data point can consist of a single piece of data, such as thickness, or multiple pieces of data, such as a color in addition to thickness.Voxelization is the process of adding depth to an image using a set of cross-sectional images known as a volumetric dataset. These cross-sectional images (or slices) are made up of pixels. A real-world distance is represented by interpixel distance which is the space between two pixels. Similarly a real-world depth is represented by interslice distance between two slices. To accurately reflect the real-world sampled volume,slices are stacked based on interpixel & interslice distance to process the dataset in computer memory. Next, additional slices are created and inserted between the dataset's actual slices so that the entire volume is represented as one solid block of data.
- Affine map & transformation:An affine space is a geometric structure that simplifies the properties of Euclidean spaces which are independent of the concepts of distance and measure of angles, keeping only the properties related to parallelism and ratio of lengths for parallel line segments.An affine transformation, affine map or an affinity is a function between affine spaces which preserves points, straight lines and planes. Affine transformations include translation, scaling, similarity transformation, reflection, rotation and shear mapping. These two dimensional transformations are modified & are treated as three dimensional transformation.
- Storing Image in PNG format with ARGB color space:It is actually simply a use of the RGB color model, with extra information. The alpha channel is normally used as antransparency channel. Pixels encoding the ARGB color space information are saved in well-defined formats. In Portable Network Graphics (PNG), the ARGB is used for encoding the intensity of each channel sample is defined by 8 bits, and are arranged in memory in such manner that a single 32-bit unsigned integer has the alpha sample in the highest 8 bits, followed by the red sample, green sample and finally the blue sample in the lowest 8 bit.

IV. RESULTS AND DISCUSSION

The number of bits of information stored per pixel of an image or displayed by a graphics adapter. The more bits there are, the more color scan be represented, but the more memory is required to store or display the image.The data is reported in Bits-per-Pixel format.Bpp or bits per pixel indicates the number of bits per pixel. The number of different colors in an image is depends on the depth of color or bits per pixel. Its formulation can be given by,
Bit per Pixel = total number of bits in final file / number of pixels in final file.
Bits-per-pixel values of different methods are as shown in table below,

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Table no.1 Bits-per-pixel values

Method Image	**<u>Proposed MILC</u>**	MILC	L-MLIC	3D-SPIHT	3D-EZW	CALIC	JPEG-LS	PPMD
CT_ Skull	**<u>1.00</u>**	2.0306	2.0683	1.955 0	2.2251	2.7250	2.8460	3.1930

In above table, compression results are compared tothe compression approaches for lossless 3-D medical images compression: MILC, L-MILC, 3D-SPIHT, 3D-EZW&approaches for 2-D image compression: CALIC, JPEG-LS and to general purpose scheme as PPMd. Our results show that the bits-per-pixel value of our proposed system is better than existing variations of MILC, nearly equivalent to 3D SPIHT approach, is half of the result of 2D approaches & twice less than general method as PPMD. All the entries are in bits-per-pixel.
PSNR is most commonly used to measure the quality of reconstruction of compression codecs. When comparing compression codecs, PSNR is an approximation to human perception of reconstruction quality of codec.PSNR is most easily defined via the mean squared error (MSE).
The mean squared error (MSE) for our practical purposes allows us to compare the “true” pixel values of our original image to our degraded image. The MSE represents the average of the squares of the "errors" between our actual image and our noisy image. The error is the amount by which the values of the original image differ from the degraded image. The proposal is that the higher the PSNR, the better degraded image has been reconstructed to match the original image and the better the reconstructive algorithm. This would occur because we wish to minimize the MSE between images with respect the maximum signal value of the image.
Table below show the average values of PSNR & MSE of 20 images compressed by our proposed approach **<u>P-MILC</u>**.

Table no. 2 Average of MSE, PSNR

Methods	**PSNR**	**MSE**
JEPG 2000	31.2	35.4
SPIHT	34.01	39.3
EZW	29.905	66.7
JPEG	28.27	96.2
P-MILC	35.256	4.1

Fig.1 shows the average value of MSE of different compression standards with proposed method P-MILC. Mean squared error (MSE) for our practical purposes allows us to compare the “true” pixel values of our original image to our degraded image. Above methods JPEG, EZW has highest MSE while methods JPEG 2000, SPIHT has the lowest values of MSE. Our proposed method has the steady rate of MSE with values in-between these methods.Lower value of MSE indicates that error is introduced at a lower rate than the other referred methods.

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Fig.1 SNR vs. MSE values of Images obtained by Different Methods

Fig.2 shows the average value of PSNR of different compression standards with proposed method P-MILC.The result shown above depicts that methods JPEG 2000, SPIHT, EZW & JPEG has a lower value of PSNR than that of our proposed method P-MILC. Our goal was to reconstruct an image which similar to the original image before compression .As the PSNR value is higher it shows that reconstructed image is similar to original image & algorithm is better reconstructive.

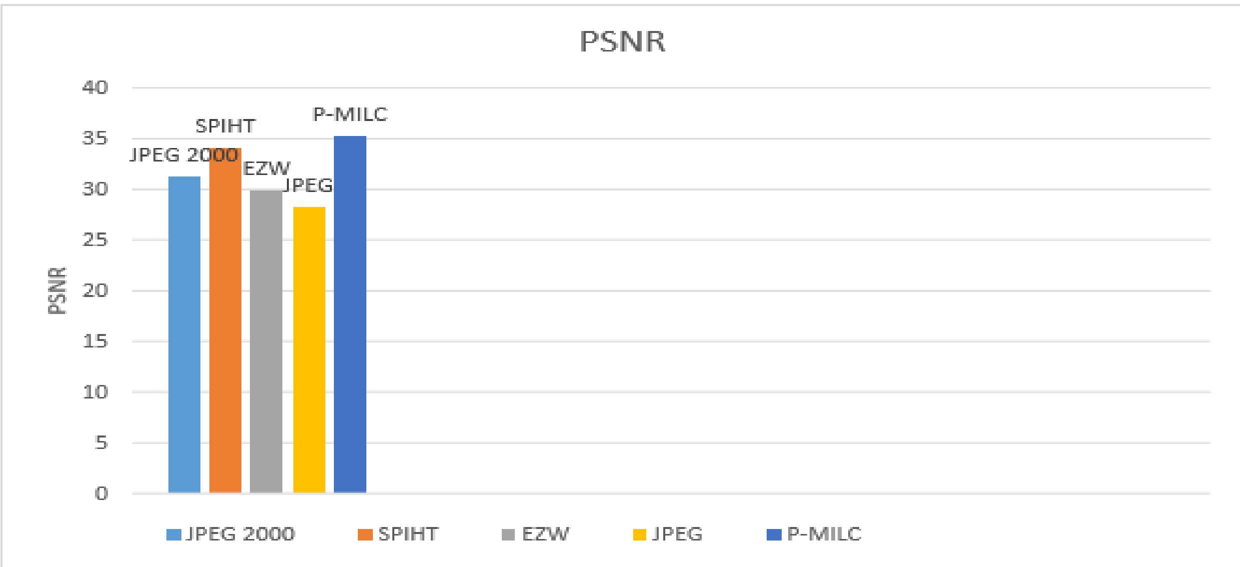

Fig.2 PSNR Values of Images obtained by different methods

V. Conclusion and Future Work

Performance of proposed system delivers result 4% better than JPEG 2000, 1% better than SPIHT method, 6% better than EZW & 7% than JPEG methods. The performances of a 3-D compression algorithms for 3-D medical images depend on slice thickness and spacing. Therefore, in many applications the performances of a 3-D coder could be

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similar to a 2-D coder, in particular when the correlation among the slices is very low. This work is the first step of a wider project. The early encouraging results I have obtained on the classification procedure prompt us to continue with other work that will aim to improve the quality of compression. Also it saves space in bandwidth while communicating or consulting with the images in network.
The proposed system is being implemented on 3D images. However there are some methods that are being developed for 4D & 5D image.Getting multiple 3D images over time prospectively to monitor & study the patient can give us 4D images.
This method can be used for diagnosis & recognizing while adding another dimension. That can be atlas, template, historical data, etc.Similarly,the pattern of deformation for dynamic cardiac CT can be used to detect, dingos & track the diseases. Furthermore it can be used along with radar images, cell & sub cell particle movement monitoring. Thus the future scope includes work on 4D & 5D images.

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BIOGRAPHY

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