A Hybrid Medical Image Compression Techniques for Lung Cancer

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Abstract

Objectives: This study focuses on Image compression and compares different methods. Methods/Statistical Analysis: In this work we simulated four image compression methods. The first method is focused on Karhunen-Loève Transforms (KLT), second method is focused on Walsh-Hadamard Transforms (WHT), third method based on FFT and fourth one is proposed sFFT. Findings: The experimental outcomes are compared with the different quality of parameters applying on numerous lung cancers CT scan images. The Proposed SFFT method algorithm was given better results like Peak Signal to Noise Ratio (PSNR), Structural Content (SC), Mean Square Error (MSE) and Compression Ratio (CR) are compare to other Transform methods. Application /Improvement: The Proposed SFFT technique gives improved result compared with other methods in all evaluation measures.

1. Introduction

The volume of medical image data produced every day in health care is ever growing, particularly in grouping with the upgraded scanning determinations and the significance of volumetric medical CT scan image data sets. The Lung cancer is the utmost common disease of the cancer passing in the world. The Tobacco smoking cause's etiology of breath and lung cancer. Several patients report no indications what so always, so it is vital that exact questions be enquired to try to produce info about symptoms they may not reflect abnormal1. In the case of an abnormal chest x-ray, the patient should directly undergo a chest CT scan for further evaluation. Figure1 shows that the unusual chest CTs inpatients who originally obtainable with weight loss and cough2. The Positron emission tomography was clarifying that the extent of the cancer3. When lung cancer is assumed, the patient stated to an oncologist, who will decide the supreme suitable diagnostic process (e.g., bronchoscopy, CT guided lung biopsy, sputum cytology or media stinoscopy) and utmost favour-

izable whole course of therapy for the lung cancer patient's specific needs4. The image compression techniques5 like KLT, WHT, FFT and Proposed sFFT were used to compress the lung cancer CT scan medical images6. The real context that defines when to usage lossy versus lossless image compression and the real parameters7 for change the image compression system are left to the ruling of the implementer and use case8,9. Image Compression standards, like as JPEG-LS or JPEG, have a very restricted fixed of options concerning their setup. In10 defined image compression is decreasing the size of digital scan medical image and graphical file, without changing on its quality.

2. Image Compression Methodology

The Image compression is method to eliminate the redundant data from the image so that only vital data can be stored to decrease the transmission time11, storing size and transmission bandwidth. Figure 2 shows that the
vital data is extracted by different transforms methods such that it can be rebuilt without dropping quality and information of the given image. In this paper focused comparative study and analysis of medical CT scan image compression was done by different four transforms techniques, they are KLT, WHT, FFT and proposed sFFT.

Figure 1. CT scan lung image.

2.1 Karhunen-Loève Transform (KLT)

Hotelling transform also called as Karhunen-Loève Transforms or KLT, minimizes MSE that is present between original (sub) image and (decompressed) reconstruction. Thus for any image KLT is the optimal information compaction transformation as well as for any number of retained coefficients. KLT basic functioning is dependent on image but, this however makes pre-computing impossible and hence this does not qualify it as a practical option suitable for image compression.

There are several applications where KLT\textsuperscript{12} has been widely used as in multi-spectral study of medical-gathered images over the resultant spectral initials of the scan imaged regions. Also there is important information reduction that is attained while storing medical CT scan images considering multi-spectral sets have been changed to KLT space. Newly KLT has been used to enable medical images in the face pack acknowledgement. It is important to the note that medical image fixed size is perhaps bigger to subsequent two uses.

Figure 2. Compression techniques.

2.2 Walsh-Hadamard Transform (WHT)

The Walsh transform from the base of Walsh system functions. The Walsh functions transforms have only -1 and +1 values\textsuperscript{13} and orthogonal. The Walsh transform function is developed by the Hadamard matrix functions as following:

\[
H_{2^k} = \begin{bmatrix} H_{2^{k-1}} & H_{2^{k-1}} \\ H_{2^{k-1}} & -H_{2^{k-1}} \end{bmatrix} \quad \forall \; k = 1, 2, \ldots \; \alpha \; H_1 = 1 \text{ for } k = 0
\]

WHT here was employed to facilitate face as well as signature recognition as WHT coefficients output array comprises only of integer values, resultantly Hadamard transform thus becomes a quick transform, and implementation is feasible in \(O(N \log N)\) additions as well as subtractions.

2.3 Fourier Transform

Fourier Transform is known to decompose image as two components: sinus and cosines. This implies that FT will transform any image from spatial to frequency domain respectively\textsuperscript{14}. Fact is that any function can be precisely approximated using sum of infinite sinus and cosines.
functions. Fourier Transform essentially is a method to execute this. Mathematically a two dimensional images Fourier transform is:

$$F(k, l) = \sum_{i=0}^{N-1} \sum_{j=0}^{N-1} f(i, j) e^{-i2\pi\frac{(k-1)(i-1)}{N}} e^{i2\pi\frac{(l-1)(j-1)}{N}} = \cos(\pi x)$$

Here \( f \) is the image value in its spatial domain and \( F \) in its frequency domain. Transformation results in complex numbers. This can be showing either using a real and complex image or using a magnitude and phase image. Though, in image processing algorithms it the magnitude image alone which is of interest as it has the information required regarding the geometric structures of the images. Nonetheless, in case there is a need to modify image in the particular forms what is required to retransform is the need to preserve both.

2.4 Fast Fourier Transform (FFT)

The FFT algorithm was developed by Carl Friedrich Gauss on 1805. Discrete Fourier Transform (DFT) is computed by the FFT. The most size \( M = N \times N \) matrix divided into small size \( N \)'s of DFT in the period field. The new-fangledRadix-2 to Decimation in Time (DIT) FFT is the operative and modest technique. This is also used in compute \( 2^n \) the point DFT. In the FFT technique the assumed weights are multiplied by the indexed. The outcomes should be in the bit opposite form of the specified input signal. The compound conjugate uniformity is used to mean the imaginary part.

2.5 Proposed Methodology (Sparse Fast Fourier Transform – Proposed sFFT)

The any given algorithms for which is used to compute the DFT essential take time at minimum proportional to its outcome size, \( \Omega(n) \). Many of the indicators in frequency field are sparse. In common signal processing methods more applications cover small significance of equal to zeroor Fourier coefficients. So the resulting DFT is around sparse. This is common in picture that is many of the coefficients are insignificant. Videos and Images are equally sparse. An effective algorithm is wanted to compute the FFT for the indications that are sparse in frequency field. \( sFFT \) computes \( k \) – sparse estimate, where the runtime depends upon \( k \), the most coefficient in the signal. In this algorithm works in the method of detecting these \( k \) values by filter \( G \).

The most speeds the runtime of these algorithms will be as following:

$$O(k \log n) \text{ or } O(k \log^2 n)$$

In some constants the \( C > 2 \).

The key important of the sFFT is its modest organization. It has an effective runtime with the low big- \( O \). Constant. In the typical case of \( n \) which is the power of 2, for runtime is

$$O(\log n \sqrt{nk \log n})$$

The research is made with 128x128 medical images to compression and decompression with KLT, WHT, FFT and Proposed sFFT and calculating PSNR, MSE, CR, SC.

2.5.1 Proposed sFFT Algorithm

The construction of the proposed algorithm has following steps:

**Step 1:** The work is complete with FFT in compute the FT in MATLAB software.

**Step 2:** The implementation of the FFT algorithm in the MATLAB software.

**Step 3:** The work is made by SFFT algorithm to compute the FT in the single array.

**Step 4:** The implementation of the SFFT algorithm Coding is based on Matlab library function and header files.

**Step 5:** The process and operation of the SFFT algorithm to computing the DFT will be \( Y_i = \sum_{j=0}^{n-1} x_j \), Here the value of \( i = \sqrt{-1} \).

3. Performance Evaluation

3.1 The Peak Signal to Noise Ratio (PSNR in dB)

Peak Signal-to-Noise Ratio also called as PSNR. PSNR approximates image quality index, however on its own it does not have the capability of drawing a comparison between the features of two distinct images. There is a possibility however that lower PSNR image may be considered as an image whose tone quality is comparatively better than one with a higher signal to noise ratio.

$$PSNR = 10 \log \frac{255^2}{MSE}$$
As several signals inherently have an extensive dynamic range, PSNR generally is expressed as logarithmic decibel scale.

### 3.2 The Mean Square Error (MSE)

MSE is expanded as Mean Square Error. MSE is the standard of the digital image quality index. Huge worth of the mean square basically implies the low quality digital image. Generally, it is a criterion that has been widely used and is representative of the classical error estimate as denoted by equation:

$$\text{MSE} = \frac{1}{MN} \sum_{j=1}^{M} \sum_{k=1}^{N} (x_{j,k} - x'_{j,k})^2$$  \hspace{1cm} (6)

Here M and N are digital image dimensions.

### 3.3 The Compression Ratio (CR)

Compression Ratio is also called as CR. The CR ratio of number bits necessary to signify the information before compression to number of the bits essential to signify information after compression.

$$\text{CR (bpp)} = \frac{\text{Number of coded bits}}{n \times m}$$  \hspace{1cm} (7)

### 3.4 The Structural Content (SC)

The SC is called as Structural content measure. SC that is employed to draw a comparison between two images inherent in several small image patches and to determine the images have in common. A comparison is drawn between patches by deploying 2D nonstop wavelet that performances as a small level corner indicator. Huge value of the SC basically implies a poor quality image.

$$\text{SC} = \frac{\sum_{j=1}^{M} \sum_{k=1}^{N} x_{j,k}^2}{\sum_{j=1}^{M} \sum_{k=1}^{N} x_{j,k}^2}$$  \hspace{1cm} (8)

### 4. Experimental Results and Discussions

The experiment is carried out in MATLAB environment. In this research, the images deployed here the compression for all 128 X 128, 8-bit medical images in the BMP picture format. Basically meaning that given images comprise of 128 X 128 = 16,384 inpixels, wherein each pixel is signified by 1 byte or 8 bits. Proposed SFFT method implementations have been carried out on MATLAB application and several different parameters should be ascertained with respect to the three medical images; comparison of reconstructed and original images PSNR, MSE, CR, SC values have been estimated.

| Medical Image Size | Medical Image CT Scan Image | Image Compression Technique Used | PSNR | MSE  | CR   | SC   |
|--------------------|-----------------------------|---------------------------------|------|------|------|------|
| 128 x 128          | CT IMAGE 1                  | KLT                             | 43.3436 | 2.342 | 2.6822 | 3.984 |
|                    |                             | WHT                             | 41.0181 | 3.165 | 3.7365 | 3.098 |
|                    |                             | FFT                             | 40.7637 | 8.437 | 4.4844 | 2.965 |
|                    |                             | PROPOSED SFFT                    | 39.7656 | 10.373 | 5.3433 | 2.615 |
| CT IMAGE 2         |                             | KLT                             | 51.9335 | 7.0676 | 1.369  | 4.534 |
|                    |                             | WHT                             | 48.5279 | 9.9067 | 2.9231 | 4.053 |
|                    |                             | FFT                             | 44.6743 | 10.0932 | 3.242  | 3.785 |
|                    |                             | PROPOSED SFFT                    | 42.3932 | 12.3254 | 4.043  | 3.166 |
| CT IMAGE 3         |                             | KLT                             | 52.8757 | 6.874  | 2.836  | 3.723 |
|                    |                             | WHT                             | 50.6854 | 7.429  | 3.1302 | 3.108 |
|                    |                             | FFT                             | 47.9874 | 10.453 | 4.043  | 2.768 |
|                    |                             | PROPOSED SFFT                    | 45.0043 | 12.842 | 5.132  | 2.564 |
In Table 1, the three CT medical image size has taken as the size of 128X128. The simulated images are using KLT, WHT, FFT and Proposed SFFT compression techniques. In first CT Image given good result in Proposed SFFT for PSNR value is 39.7656 less than KLT, WHT and FFT value is 43.3436, 41.0181 and 40.7637 respectively. In second CT Image get the good result in Proposed SFFT for PSNR value is 42.3932 less than KLT, WHT and FFT value is 51.9335, 48.5279 and 44.6743 respectively. In third CT Image gives good result in Proposed SFFT for PSNR value is 45.0043 less than KLT, WHT and FFT value is 52.8757, 50.6854 and 47.9874 respectively. In the given Table 1, Charts, Figure 1,2,3,4,5,6 are clearly discuss about the PSNR, MSE, CR and SC parameters. The Proposed SFFT method gave less SC value or given three CT image. Also it produced high MSE and CR Value compare to the other exiting methods.

![PSNR VALUE](image)

**Figure 3.** Graph shows that PSNR evaluation values take 128X128 size three CT scan images with KLT, WHT, FFT and proposed SFFT.

## 5. Conclusion

This paper made comparison among four important KLT, WHT, FFT and Proposed SFFT methods of image compression. The proposed SFFT exhibited, after compression, the parameters like PSNR values, MSE, Compression ratio and SC values which were found to be better compared to other methods. The proposed SFFT takes less PSNR value and SC value than KLT, WHT and FFT. The Proposed method has more compression ratio and MSE than KLT, WHT and FFT.

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