LOSSLESS IMAGE COMPRESSION USING TETROLET TRANSFORMATION

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Abstract

This review paper deals with the image compression technique by preserving image quality. The demand for images of multimedia is drastically increasing over the past decade, resulting in insufficient storage space and bandwidth. Due to this, the strategy of compressing the images is becoming more and more significant. This may result in decreasing the usage of expansive hard disks and transmission bandwidths. Images compressed with a high compression rate affects the quality of the image. Tetrolet transform is Harr type of wavelet transform that is supported by localized orthonormal tetrominoes which in turn are shapes made by connecting four equal-sized squares. A summary of various researches on Haar Wavelet transform and Tetrolet Transform for image compression are expressed in this paper.

Keywords · *Haar wavelet Transform · Image Compression · Tetrolet transformation · Tetrominos · Wavelet Transform ·*

1 Introduction

In contemporary digital evolution, Images are taking a significant part in almost every domain. Larger amounts of image-related data are being generated, transmitted, and stored every minute. To accompany these amounts of data more bandwidth and storage space are required. To make the efficient utilization of the bandwidth and storage, image compression is to be performed. Image compression is the technique performed to remove the redundant information from the image, which means irrelevant i.e., the image pixels that are not identified by the Human Visual System and duplicate data.

Image compression can be categorized as Lossy compression and Lossless compression. Lossy compression refers to the method of compressing the data of an image by discarding the expendable data. In the Lossy compression, the quality of the image is compromised. Whereas Lossless compression refers to the method of compressing the data of an image without reducing the quality of the image. It is done by removing the metadata unwanted from the image.

The Evolution of the image compression technique was started with a Discrete Cosine Transform (DCT). It is a lossy compression technique that becomes the baseline for the JPEG image compression, Wavelet Transform is developed from the DCT and is used as a baseline for the JPEG 2000 standard. Extension of Motion JPEG 2000 is used as the baseline for video coding in JPEG 2000. DEFLATE is the lossless image compression algorithm which is used as the baseline for PNG format.

2 Wavelet Transform

Wavelet Transform is the most widely used compression technique in present days. In general, the equation to express the Wavelet Transform is following

$$F(a,b) = \int_{-\infty}^{\infty} f(t)\Psi^{*}_{(a,b)}(t)\,dt$$

Where * refers to the complex conjugate and Ψ is the function.

The Wavelet transform technique is more widely used due to the properties of energy compaction, degree of smoothness, symmetry, and orthogonality[1].

Haar Wavelet Transform: The Haar Wavelet Transform can be expressed as

$$\psi(t) = \begin{cases} 1 & 0 \le t < 1/2, \\ -1 & 1/2 \le t \le 1, \\ 0 & otherwise. \end{cases}$$

In Harr wavelet transform initially the mother wavelet with great frequency resolution i.e., we have the complete frequency of the signal but the time interval where the frequency located is to be identified. To Identify the frequency, perform a parameter scaling of the wavelets. This means the wavelet is divided into two halves and again translation is done on each part. By continuing this process at a particular level of scaling the higher frequency information is identified with greater time resolution.

3 Tetrolet Transform

Tetrominoes are shapes formed by the union of four squares connected by edges[2]. There are five different shapes that are formed from the unique combinations are called free tetrominoes, see in Fig. 1. According to Larsson, on combining these shapes there can be 117 possible solutions are formed of 4X4 board disjoint converings each with four tetrominoes. On increasing the board size the number of possible solutions will be increased. So, to handle the solutions effectively we restrict board size to 4X4. Now the image has to be partitioned to 4X4 squares to apply the tetrominoes. With the combination of these tetrominoes, 22 fundamental solutions are formed irrespective of reflections and rotations.

In a 2-D Haar wavelet, the tetromino partition will be formed due to wavelet decomposition. Tetrolet transformation is defined based on the adaptive Haar wavelet transform. By recalling the Haar wavelet transform the notations are consistent to the tetrolet. In a 2X2 square, the averaging sum and the averaging difference for each of 4 pixel values will gives the low pass filter coefficients and the high-pass filter coefficients.

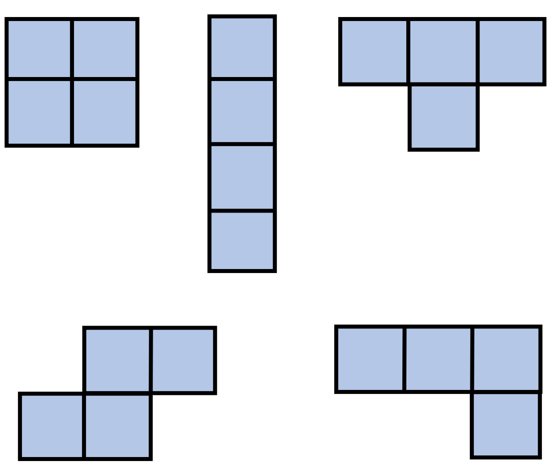

Fig. 1. Different shapes of tetrominoes**.**

The tetrolet decomposition algorithm is given below:

Input: Image **Img.**

1. Divide the image into 4X4 blocks.
2. In each block identify the sparsest tetrolet representation.
3. Form a 2X2 block by rearranging the low-pass and high-pass coefficients.
4. Store the tetrolet coefficients which are referred to as high-pass coefficients.
5. Repeat steps 1 to 4 for each low-pass image.

Output: Decomposed image of **Img**.

The flow of Tetrolet transform for the compression of the image is given as a block diagram in Fig. 2.

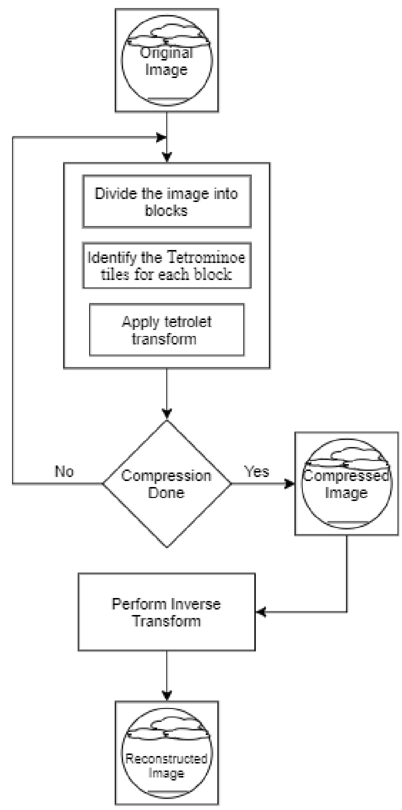

Fig. 2. Block diagram of Tetrolet Transform

In the algorithm, we have divided the input image into 4X4 Pixel blocks. As the block size is considered as N = 4 and the level-1 Haar approximation stores the matching tetrominoe tile of blocks. On calculating the low-pass coefficients and high-pass filter coefficient, the low-pass filter coefficients are again formed into the tetrominoes tiles and repeat the process.

To reconstruct the original image, Inverse Tetrolet Transform must be applied the compressed image. In general, the inverse transformation is performed to generate 2-D and 3-D images. In Inverse Tetrolet Transform the initial step is to select the detail and approximation coefficients of the sub images. Then the Inverse level-1 Haar Transform is to be performed. And identify the low-pass and high-pass filter coefficients of the tiles and are rearranged to repeat the process. Finally, all the sub blocks are combined to form the original image.

4 Literature Survey

UmaMaheswari and Srinivasa (2019) [1] by using tetrolet transform the image can be obtained with low noise and high quality even the image compression done with high encoding time. This explains that by using tetrolet transform the image can be compressed faster with high quality of the image. Images used in medical applications Such as CT scan and MRI there need to have high quality to observe the details clearly and need to perform efficient compression of these images. This can be obtained with tetrolet transform using Haar Wavelet encoding.

Jens Krommweh (2010) [2] examined the tetrolet transform and its different modifications for better compression by reducing the cost. It states that the modification in the adaptive cost will be reducing the entropy with a small loss in the quality, some balancing is to be done to maintain both. For the reconstruction, the modified tetrolet will reduce the decomposition time with the same computational time compared to the original tetrolet transform. In image denoising using tetrolet transform, there is a need to perform pre-processing along with the transformation for better performance.

Lotfi Chaari (2019) [3] has introduced a transform called grouplet transforms which can perform well in processing the geometrical image regularities. In grouplet transform the image coefficients are grouped based on the geometrical considerations. Here the grouplet transform approach is based on a fixed association field called *a priori*. Here Bayesian way is used in identifying the fields of association and the processed image content is been associated with this field. Using Markov Chain Monte Carlo (MCMC) algorithm inference is conducted on the proposed model i.e., hierarchical Bayesian model which is highly flexible and automate level. The wavelet transforms have the wide applications over compression and restoration. On testing the proposed model on multiple standard images, the wavelet coefficients are obtained in terms of quantitative and association field quality properties. The coefficients obtained are observed to be having low level of correlation and highest level of energy are concentrated within 20 percent of most significant. This explains that the grouplet transform is having significant potential in image compression and restoration applications.

Kadam S, Rathod VR (2019) [4] explains that for medical images the quality is been reduced due to the noise interface. The size of the medical images is high, and it will affect the transmission of the image. To overcome this problem image compression is to be performed. Using lossy compression, the compression ratio is very high, but the image cannot be recovered completely. But in medical image recovery of the original image is essential. So, for this lossless compression is performed where the compression ratio is less, and the quality of the image is preserved. Explained the denoising of the image using a wavelet transform using a three-stage methodology. Multi-resolution is applied to multiple standard images like fundus, magnetic resonance, and mammography images.

S Thayammal, D Selvathi (2014) [5] proposed compression of a multispectral image using tetrolet transform. In multispectral images geometrical features are important, but when Shearlet-Based Image Compression (SBIC) is used it fails in reconstructing the image due to visual cognitive effect around the geometrical features because of the high compression ratio. We can preserve the geometrical features of the multispectral images by using tetrolet transform due to the existence of orthonormal functions. The compression is achieved by threshold and encoding. Image reconstruction is done using decoding and inverse tetrolet transform. By applying the tetromenous basis functions on the tetrominoes blocks, the performance is observed to be comparatively higher than Shearlet Based Image Compression that is relying on the factors like compression ratio, bits per pixel, and peak signal to noise ratio.

Sulaiman, Nazir , Hussain, Amjad and Ayaz (2019) [6] compares the image compression approach of haar wavelet transform with discrete cosine transform and run length encoding with high compression rates. In this approach initially the image is converted to a detailed level which is half of the original image size and then the image is compressed. For instance, the image is divided into 838 blocks then the compression is applied. To obtain the original image inverse transform is applied on the 838 processed blocks. Now on comparing the results obtained from the three algorithms with different images it infers that Haar wavelet transform have the better performance in account of quality of the image and computational time.

Eva Hostalkova, Oldrich Vysata, Ales Prochazka (2007) [7] explains the approach of implementing the Haar wavelet transform on volumetric magnetic resonance images with heavy noise. The evaluation of Haar wavelet transform is done in two ways. One is with a two-dimensional approach that is applied to each individual image layer and the other is by considering the whole image volume as one and applying three-dimensional technique. The results obtained from both the approaches infer that the three-dimensional approach works very well on denoising the image when compared with the two-dimensional approach. So, the three-dimensional Harr wavelet transform can significantly improve the image quality and noise reduction when compared to the two-dimensional Haar wavelet transform.

5 Conclusion

This paper briefly discusses the image compression using Tetrolet transform. By using tetrolet transform the image can be compressed without any loss of information and high performance. Multispacial and sparse image representation can be done efficiently using tetrolet transform. In tetrolet transform due to the implementation of tetrominoes on the image blocks the compression is efficient and the quality is high. The efficiency of the compression is compared based on the factors like Peak signal to noise ratio, compression ratio, entropy, and bits per pixel.

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