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Image Compression Using Wavelet and Its Advance Family

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Abstract - Uncompressed multimedia data requires large storage capacity and transmission bandwidth. Rapid progress in mass storage density processor speeds and digital communication system performance, demand for data storage capacity and transmission data bandwidth continues to outstrip the capabilities of available technologies. The growth of data intensive multimedia-based web applications have not only sustained the need for more efficient ways to encode signals and images but have made compression of signals central to storage and communication technology.

For image compression, the joint photographic experts group (JPEG) standard is established. The performance of these codes generally degrades at low bit rates mainly because of the underlying block-based Discrete cosine Transform scheme. More recently, the wavelet transform has emerged as a cutting edge technology within the field of image compression. Based on wavelet image compression provides substantial improvements in the picture quality at higher compression ratios. Over the past few years, the powerful verities wavelet based schemes for image compression have been developed and implemented.
Keywords—Wavelet, Compression, Lossy, Subsingling

I. INTRODUCTION

Images contain huge amounts of information that requires much storage space, transmission bandwidths and long transmission times are large. So it is advantageous to compress the image by storing only the essential information needed to reconstruct the image. An image is a matrix of pixel values. To compress the image, redundancies must be exploited. So images having large areas of uniform colour will have large redundancies, and conversely images that have large changes in colour will be less redundant and harder to compress. Wavelet is used to divide the information of an image into approximation and detail sub signals. The near value subsignal shows the general trend of pixel, and three detail sub signals show the vertical, horizontal and diagonal information or changes in the image. If very small detiles, then they can be set to zero without changing the significantly of image. The greater number of zeros more compression that can be achieved. The amount of information given by an image after compression and decompression is known as the energy retained and this is proportional to the sum of the squares of the pixel values. If the energy retained is 100% then the compression is known as lossless, the image can be reconstructed exactly.

II. WAVELET

Wavelets are mathematical functions that divided data into different frequency components. The idea behind wavelets is to analyze the signal at different scales.

A. DWT and sub signal encoding

The Discrete Wavelet transform provides sufficient information for the analysis and synthesis of a signal, but is advantageously, much more efficient. DWT analysis is computed using the concept of filter banks. Filters which has different cut-off frequencies analyze the signals at different scales. Resolution changed by the filtering, the scale is changed by up and down sampling. If signal is put through two filters:

1) A high-pass filter, high frequency information kept, low frequency information lost.
2) A low pass filter, low frequency information kept, high frequency information lost.

Then the signal is effectively decomposed into two parts, a detail part (high frequency), and an approximation part (low frequency). The subsignal produce from the low filter will have a highest frequency equal to half that of the original. According to Nyquist sampling, change in frequency range means that only half of the original

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samples need to be kept in order to perfectly reconstruct the signal. Specifically this means that up sampling can be used to remove every second sample. The scale has been doubled. The resolution also changed, the filtering made the frequency resolution better, but reduced the time resolution. The approximation subsignal, then be put through a filter bank, and this is repeated the process until the required level of decomposition reached.

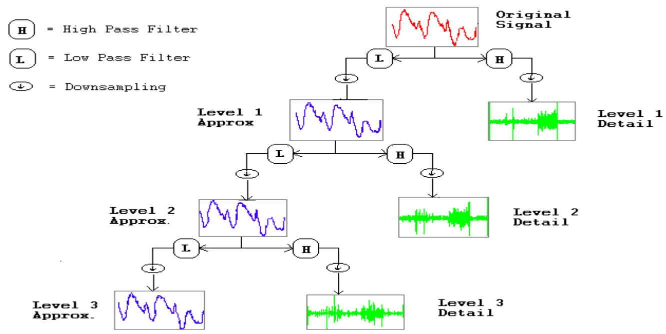

Fig 1. Level of decomposing using filter

The Discrete wavelet transform is obtained by collecting together the coefficients of the final approximation subsignal and all the detail subsignal.

III. IMAGE COMPRESSION

Data compression is the process of convert data into small files for efficiency of storage and transmission as one of the enabling technologies of multimedia revolution, data compression is key to rapid progress being made in information technology.

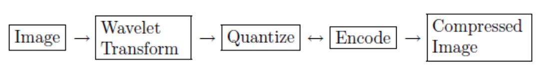

Fig2. Image compression process

In the DWT, an image signal can be analyzed by passing it through an analysis filter bank followed by a decimation operation. This analysis filter bank, which consists of low pass and high pass filter at each decomposition stage, is widely used in image compression.

Quantization refers to the process of approximation the continuous set of value in the image with a finite set of value. The input to quantizer is the original data and the output is always a finite number of level. The quantizer is a function whose output value are discrete and usually finite. The process of approximation and a good quantizer is one which represent the original signal with minimum loss of data. The quantized data contains redundant information, it is waste of storage space if to save the redundancies of quantized data. To overcoming this problem use entropy encoding. It is an example of a lossless data compression technique that provide a means of removing the Redundancies in the quantized data without any loss of data.

B. Lossless compression techniques

As the name indicates the original image can be perfectly recovered by using the lossless compression techniques. They are also called as entropy coding, noiseless compression etc. They cannot introduced any noises to the image and they are using statistics or decomposition techniques to reduce the redundancy. They are preferred for medical imaging, technical design etc. The following are some methods which are used for lossless compression.

1) Run length encoding.
2) Entropy encoding.
3) Area coding.

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C. Run length encoding

This method is a lossless compression method. It is mainly use for sequential data. This is useful on data that contains repetitive information. This method will replace by identical symbols these identical symbols are known as runs. They are replaced by short symbols. This technique is supported by most bitmap file formats, such as TIFF, BMP, RLE, JFET is suited for compressing any type of data regardless of its information, but the content of the data will affect the compression ratio achieved by RLE. Although most RLE algorithms not achieve the high compression ratios of the advanced compression methods, Run Length Encoding is easy to implement and quick to execute, so it making a good alternative to either using a complex compression algorithm or leaving your image data uncompressed. There are numbers of variants of run-length encoding. Image information is normally run-length encoded in a sequential process that treats the image data as a 1 Dimension stream, rather than as a 2 Dimension map of data. In sequential processing, a bitmap is encoded starting at the upper left corner and proceeding from left to right across each scan line to the bottom right corner of the bitmap. But alternative run length encoding schemes can also be written to encode data down the length of a bitmap along the columns to encode a bitmap into 2D, or even to encode pixels on a diagonal in a zig-zag fashion Odd RLE variants such as this last one might be used in highly specialized applications but are usually quite rare**.**

D. Entropy encoding

Entropy encoding is other lossless compression technique. It work independent of the specific characteristics of medium. By using it as a compression technique, it can be also used to measure the similarity in data streams. It creates a unique prefix code and assign this code to unique symbol in the input. Unlike RLE, entropy encoder works by compressing data by replacing the fixed length output with a prefix code word. This is varying the size after creating the prefix code. This will similar to the negative logarithm of probability. There are number of entropy coding methods. Most common techniques are ‘Huffman coding’ and arithmetic coding Huffman coding was developed by David A. Huffman. It would use a variable-length code table for encoding a source symbol where it has been derived in a particular way based on the estimated probability of occurrence for each possible value of the source symbol. The prefix codes used in this technique is known as prefix- free codes. This technique is similar as block encoding technique and it is optimal for symbol by symbol encoding. So when symbol by symbol restriction is dropped it cannot be optimal.

E. Area Encoding

Area encoding method is an enhanced form of run length encoding method. In constant area coding special code words are used to identify large number of contiguous 0’s and 1’s. Here the image is segmented in to blocks and then the segments are classified as blocks which only contains black pixels or white pixels or blocks with mix intensity. Another variant of constant area coding is to use an iterative approach in which the image (binary) is decomposed into successively smaller and smaller block .A hierarchical tree built from these blocks. When the block reaches the section stop to certain predefined size or when every pixels of the block have the same value, nodes of this tree are then coded. For compressing white pixel text a simpler approach is used. This is called as white block skipping. Blocks containing solid white areas are coded to binary 0 and all other areas are coded to 1.

F. Lossy compression techniques

Lossy schemes provide higher compression ratios than lossless schemes. The decompressed image is not identical to the original image, but reasonably close to it. This scheme is widely used. Lossy methods are especially suitable for natural images such as photographs in applications where minor loss is acceptable to achieve a reduction in bit rate. The lossy compression that produces difference known as visually lossless. Lossy compression method are as following.

1) Chroma subsampling
2) Transform coding
3) Fractal Compression

G. Chroma subsampling

This takes advantage of the fact that the human eye perceives spatial changes of brightness sharply than those of colour, by averaging or dropping some of the chrominance information in the image. It works by taking advantage of the human visual system's lower acuity for colour differences than for luminance. It is widely used in video encoding, JPEG encoding. Chroma sub sampling is a method that stores colour information at lower resolution than intensity information. The majority of graphics programs perform 2x2 chroma sub sampling, which breaks the image data into 2x2 pixel blocks and only stores the average colour information for each 2x2 pixel group.

H. Transform coding

Transform coding is a type of compression for natural data like photographic images. TC will result a low quality output of original image. It is a core technique recommended by JIFT. Transform coding is convert the spatial image pixel values to transform coefficient values. Since TC is a linear process and no information is lost, the number of coefficients produced and pixels transformed is equal.

I. Fractal Compression

Fractal compression is one of the lossy compression technique used in digital images. As the name indicates it based on the fractals. This is good for natural images and textures. It works on the realty that parts of an image can resemble other parts of the same image. These data are known as “fractal codes” Which are used to recreate the encoded image.

IV. ADVANCE FAMILY OF WAVELET

Wavelet provide a very spares and efficient representation for divided piecewise smooth signals, but it cannot efficient represent discontinuities along edges or curves in image or object. This weakness of wavelets in higher dimension can be overcome by curvelets and redgelets. The curvelets and redgelets providing efficient represention of piecewise smooth object with discontinuities along curve.

A. Ridgelets

Image processing tasks take advantage of sparse representations of image data where most information is packed into a small number of samples. Typically, these representations are achieved by invertible and non-redundant transforms. Now a days, the most popular choices for this purpose are the wavelet transform and the discrete cosine transform. The success of wavelets is mainly due to the good performance for piecewise smooth functions in 1D. Unfortunately, such is not the case in 2D.Wavelets are good at catching zero-dimensional or point singularities, but the 2-dimensional piecewise smooth signals resembling images have one-dimensional singularities. That is, smooth regions are divided by edges, and while edges are discontinuous across, they are typically perfect smooth curves. Intuitively, wavelets in 2D are obtained by a tensor-product of 1D wavelets and they are thus good at isolating the discontinuity across an edge, but cannot see the smoothness along the edge.

The weakness of wavelets in higher dimensions can be overcome, recently pioneered a new system of representations named ridgelets which deal effectively with line singularities in 2 dimensional. The wavelet transform can be used to effectively handle the point singularity in the Radon domain.

Radon transforms that can lead to invertible discrete ridgelet transforms with appealing some properties. A discrete ridgelet transform can achieves both invertibility and non-redundancy. Construction leads to a large family of orthonormal and directional bases for digital images, including adaptive scheme. The inverse transform is numerically stable and the same algorithm can be used as the forward transform its a result. Because a basic building block in construction is the Radon transform, which has a wrap-around effect, ridgelet transform is not geometrically faithful.

B. Curvelet

Curvelet transform is a new muliscale transform designed to represent edges and other singularities along curves more efficient than the traditional transform using fewer coefficient for a given accuracy of reconstruction.

Curvelet transform is like wavelet transform, is muliscale transform, with frames elements indexe by scaler and location parameters. As wavelet transform, curvelet has directional parameter, and the curvelet pyramid contains element with a very high degree of directional specificity. It is based on a certain anisotropic scaling principle, which quite different from the isotropic scaling on wavelets. By special scaling law, where the length of support of a frame element and the width of the support are linked by the relation

Width $= lenght^2$.

It based on multiscale ridgelet combined with a spatial bandpass filtering operation to isolate different scale. Curvelets occur at all scale, locations, and orientation. While ridgrlets have global length and variable widths, curvelets gives an addition to a variable width and have a variable length and so variable anisotropy. The length and width at one scale are related by a scaling law width and length.

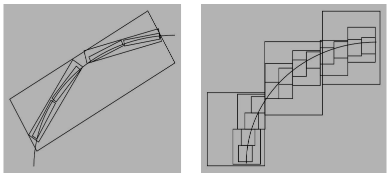

Fig3. compression between wavelet and curvelet

V. CONCLUSION

These image compression techniques are basically classified into lossy and lossless technique. Image compression using wavelet transforms results in an improved compression ratio and image quality. Wavelet transform is only method that provides spatial and frequency domain information. These properties of wavelet transform greatlly help in identification as well as selection of significant and non significant coefficient amongst wavelet transform. Wavelet transform technique provides the most promising approach to high-quality image compression, which is essential for lot of real world applications.

Digital image is use in computer application. Uncompression digital image require large storage capacity and transmission bandwidth. Efficient image compression is becoming more critical with recent growth of data intensive, media based web applications.

Ridgelet and curvelet is the best scheme for image compression. Its application in image or signal denoising and its reconstruction. Typically area of application includes astronomical image, seismic processing and imaging, representation of wave propagation phenomena. Because it provide very sparse representation of image with edges on piecewise smooth curve or function containing smooth regions and also edges, curvelets have great potential for image processing.

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