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Image Compression using DWT Interpolation Technique

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Abstracts

Human Vision interpolation phenomenon at optimum computational load. Image can be zoomed in or zoomed out using various interpolation techniques. Here, Lifting Scheme is used as a tool to increase/decrease image size, even though image is not of size 2n x 2n where n is an integer. Zero padding technique is used for images those are not of size 2n x 2n dimensions. Any variable size reduction/magnification of an image can be computed using the proposed lifting scheme. For this, piecewise application of Lifting Scheme based DWT is presented.

With the advent of satellites, which are having higher resolutions, the compression of image has become a necessity to reduce mass meet the bandwidth requirement. The wavelet transform has emerged as a cutting edge technology, in the field of image compression. Wavelet-based coding provides substantial improvements in picture quality at higher compression ratios.

Keywords: Image Compression, DWT interpolation.

Introduction

The advent of satellites, which are having higher resolutions, the compression of image has become a necessity to reduce mass (reduction in storage) as well as to meet the bandwidth requirement. The wavelet transform has emerged as a cutting edge technology, in the field of image compression. Wavelet-based coding provides substantial improvements in picture quality at higher compression ratios.

Wavelet transform have proven to be useful tools for several applications including signal analysis, signal compression and numerical analysis. A discrete wavelet transform or two band sub band filtering with finite filters can be decomposed into finite sequence of simple filtering steps, which we call lifting steps but are also called as ladder structures. This decomposition corresponds to factorization of polyphase matrix into elementary matrices which is done by the use of the Euclidian algorithm.

BASICS OF WAVELETS

The transform of a signal is just another form of representing the signal. It does not change the information content present in the signal. The Wavelet Transform provides a time-frequency representation of the signal. It was developed to overcome the short coming of the Short Time Fourier Transform (STFT), which can also be used to analyze non-stationary signals. While STFT gives a constant resolution at all frequencies, the Wavelet Transform uses multi-resolution technique by which different frequencies are analyzed with different resolutions. Wavelets are functions defined over a finite interval and having an average value of zero. The basic idea of the wavelet transform is to represent any arbitrary function as a superposition of a set of such wavelets or basis functions. These basis functions or baby wavelets are obtained from a single prototype wavelet called the mother wavelet, by dilations or contractions (scaling) and translations (shifts).

A wave is an oscillating function of time or space and is periodic. In contrast, wavelets are localized waves. They have their energy concentrated in time or space and are suited to analysis of transient signals. While Fourier Transform and STFT use waves to analyze signals, the Wavelet Transform uses wavelets of finite energy.

CONTINUOUS WAVELET TRANSFORM

The continuous wavelet transform evolved as an alternative approach to STFT to overcome the resolution problem. The wavelet transform is similar to the STFT in that the signal is multiplied by a function similar to windows function in STFT, but the transform is done separately for different segments of the signal. The main differences between the STFT and the CWT are that in CWT, the width of the window is changed as the transform is computed for every single spectral component. High scales give global information of a signal (that usually spans the entire signal), whereas low scales give a detailed information of a hidden pattern in the signal (that usually lasts a relatively short time). In

practical applications, low scales (high frequencies) do not last for long, but they usually appear from time to time as short bursts. High scales (low frequencies) usually last for the entire duration of the signal. The effect of this shifting and scaling process is to produce a time-scale representation. which employs a windowed FFT of fixed time and frequency resolution, the wavelet transform offers superior temporal resolution of the high frequency components and scale (frequency) resolution of the low frequency components. This is often beneficial as it allows the low frequency components, which usually give a signal its main characteristics or identity, to be distinguished from one another in terms of their frequency content, while providing an excellent temporal resolution for the high frequency components which add the nuance's to the signals behavior.

Discrete wavelet transform

The foundations of DWT go back to 1976 when techniques to decompose discrete time signals were devised. Similar work was done in speech signal coding which was named as sub-band coding. In 1983, a technique similar to sub-band coding was developed which was named pyramidal coding. Later many improvements were made to these coding schemes which resulted in efficient multi-resolution analysis schemes. In the case of DWT, a time-scale representation of the digital signal is obtained using digital filtering techniques. The signal to be analyzed is passed through filters with different cut-off frequencies at different scales. The original signal is successively decomposed into components of lower resolution, while the high frequency components are not analyzed any further. The maximum number of decomposition that can be performed is dependent on the input size of the data to be analyzed, with 2N data samples enabling the breakdown of the signal into N discrete levels using the discrete wavelet transform.
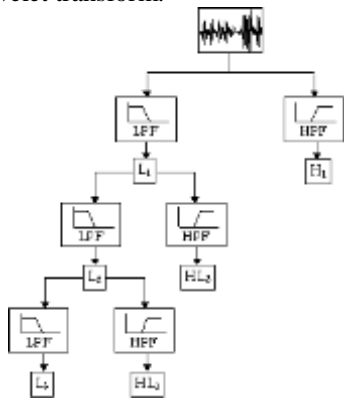

Fig1.Filter bank representation of DWT decomposition.

Applications of wavelet transforms

There is a wide range of applications for Wavelet Transforms. They are applied in different fields ranging from signal processing to biometrics. One of the prominent applications is in the FBI fingerprint compression standard. Wavelet Transforms are used to compress the fingerprint pictures for storage in their data bank. The previously chosen Discrete Cosine Transform (DCT) did not perform well at high compression ratios. It produced severe blocking effects which made it impossible to follow the ridge lines in the fingerprints after reconstruction. This did not happen with Wavelet Transform due to its property of retaining the details present in the data.

Wavelet based image compression

In many applications wavelet-based schemes (also referred as sub band coding) outperform other coding schemes like the one based on DCT. Since there is no need to block the input image and its basis functions have variable length, wavelet coding schemes at higher compression avoid blocking artifacts.
Wavelets are ideal for processing natural images and outperform traditional DCT compression, as used in the prevailing JPEG standard- Wavelet transform have non-uniform frequency spectra, which facilitate multi-scale analysis; The multi-resolution property of the wavelet transform can be used to exploit the fact that the human eye's capacity to detect noise deteriorates at high and low frequencies. This is because most of the energy of wavelet transformed data is concentrated in the low frequency region; The DWT can be applied to an entire image without imposing a block structure as used by the DCT, so there is less distortion.

LIFTING SCHEME

Lifting scheme of wavelet transform implementation came into existence in 1994 Its main advantages are it works in spatial/time domain and does not depend on the Fourier transform. In view of this, it is more intuitive and less mathematical and is suitable for application engineers/scientists. It exploits basically the correlation/structure of the signal. Further it can be generalized to complex geometric situations like computer graphics and geosciences.

Conclusion

Lifting Scheme is used as a tool to resize an image to any extent. Image can even be reduced to 2 pixels and its reconstruction using inverse Lifting scheme is achieved. Image compression is of prime importance in Real time applications like video conferencing where data are transmitted through a channel. Here detailed mathematical approach on wavelet based lifting scheme

which is computationally efficient compared to the traditional convolution method. The results provided the fact that wavelet-based coding provides substantial improvements in picture quality at higher compression ratios.

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