DSP IMPLEMENTATION OF IMAGE COMPRESSION BY MULTIRESOLUTIONAL ANALYSIS

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Abstract

Wavelet algorithms allow considerably higher compression rates compared to Fourier transform based methods. The most important field of applications of wavelet transforms is that the image is captured in few wavelet coefficients. The successful applications in compression of image or in series of images in both the space and the time dimensions. Compression algorithms exploit the multi-scale nature of the wavelet transform.

Keywords

Wavelet Transform, Multiresolutional Analysis, Image Compression, Digital Signal Processing

1. Image Compression - Statement

The effective algorithms are used in images to be compressed. The programming of algorithms is done in MATLAB System. Artificial images are used in choosing the method of evaluation of wavelet algorithms. The real ultrasonographic images are considered as monochromatic maps of vectors.

Image compression techniques are very suitable for storing or sending images using as few bite as possible for encoding a complete image. A compressed image can either be exactly equal to the original image, or differ from it in a limited and controlled way. The general image processing scheme consist among other of some typical steps as decomposition, compression, decompression and reconstruction of the given image.

2. Basis of Theory

In our contribution we consider the $M{\times}M$ matrix with elements $c_{mn}^{(0)}$ as the result of decomposition process, and aim at its data compression in such a way that full reconstruction is possible. We use the two dimensional multiresolution analysis [1], where we denote ϕ the generator of a compact supported multiresolution wavelet basis satisfying dilation equation

$$\phi(x) = \sqrt{2}\sum_{0}^{2N-1} h_k \phi(2x-k) \ ,$$

and, we obtain the accompanying „mother“ wavelet ψ defined by

$$\psi(x) = \sqrt{2}\sum_{0}^{2N-1} g_k \phi(2x-k), \ g_k = (-1)^k h_{1-k} .$$

The multiresolution transform of the matrix signal $c^{(0)}$ is described at j-th level by the recursions

$$P_j c^{(0)} = \sum_{mn} c_{mn}^{(j)} \phi_{jm}(x) \phi_{jn}(y) \ ,$$

$$Q_j c^{(0)} = \sum_{mn} d_{mn}^{(x)(j)} \psi_{jm}(x)\, \phi_{jn}(y) +$$

$$+ d_{mn}^{(y)(j)} \phi_{jm}(x)\, \psi_{jn}(y) + d_{mn}^{(xy)(j)} \psi_{jm}(x)\, \psi_{jn}(y)$$

It is important that these calculation can be performed easily as matrix operations with suitable implementation in hardware because likewise hold the recursion relations

$$c^{(j+1)} = \mathbf{H} c^{(j)} \mathbf{H}^T, \quad d^{(x)(j+1)} = \mathbf{H} c^{(j)} \mathbf{G}^T,$$
$$d^{(y)(j+1)} = \mathbf{G} c^{(j)} \mathbf{H}^T, \quad d^{(x)(j+1)} = \mathbf{G} c^{(j)} \mathbf{G}^T,$$

where the matrix operators **H**, **G** are sparse $M/2{\times}M$-matrices composed from the h_k, g_k coefficients, respectively [2]. The signal $c^{(j+1)}$ is the coarse scale information, and, there are three difference signals: $d^{(x)(j+1)}$, $d^{(y)(j+1)}$, $d^{(xy)(j+1)}$. As shows the above construction scheme, the size of low scale image is a quarter of the size of the original image. Hence the number of the difference signal coefficients is three times as large, but corresponding values are very small or zeros. This effect plays an important role by storing and sending of the compressed data.

Since the used wavelet bases are orthonormal at any level [3] the reconstruction algorithm is defined by the simple recursion formula as well, because the wavelet bases properties imply the orthonormality of the transform matrices.

The pictures show an example computed with given Daubechies' wavelet coefficients $h_0,\ldots,h_3$ [2]. The original is in the Figure 1 while the Figures 2 and 3 represent results of the compression in the x, y - axes direction, respectively. The main information about the original image is compressed in upper left corner and other parts of the figure contain different signal. The Figure 4 shows the reconstructed image without using the different field components.

Figure 1: Original digitised picture

Figure 2: Fifty percent compression

Figure 3: Twenty five percent compression

Figure 4: Reconstruction of the picture

Algorithms of wavelet computation require the high speed matrix multiplying. An optimal solution of high performance computation have its power in more advanced address manipulation.

3. DSP Real-Time Implementation

The multidimensional array addressing supports the arithmetic section of Digital Signal Processor (DSP) TMS320C50. The raw computation power of DSP is in the Complex Arithmetic and Logic Unit (CALU).

The CALU can directly read from or write to the auxiliary registers. The Arithmetic Address Unit (ARAU) updates of the auxiliary registers during the decode phase (the second machine cycle) of pipeline. The ARAU may autoindex the current auxiliary register while the data memory location is being addressed. Indexing either by ±1 or by the contents of the Index Register INDX.

As a result, accessing tables of information does not require the CALU for the address manipulation; thus the CALU is free for other operations in parallel. The INDX can be added to or subtracted from auxiliary register, which is controlled by auxiliary register pointer (ARP), on any AR update cycle. The INDX is one of memory-mapped registers and is used to increment the address in step of large two (due to the matrix operators **H**, **G** morphology):

$$\mathbf{H}=\begin{pmatrix} h_0 h_1 h_2 h_3 0\, 0 \cdots 0\, 0 \\ 0\, 0\, h_0 h_1 h_2 h_3 \cdots 0\, 0 \\ \cdots\cdots \\ h_2 h_3 0\, 0 \cdots 0\, 0\, h_0 h_1 \end{pmatrix}, \quad \mathbf{G}=\begin{pmatrix} g_2 g_3\; 0\; 0 \cdots 0\; 0\; g_0 g_1 \\ g_0 g_1 g_2 g_3\; 0\, 0 \cdots 0\; 0 \\ \cdots\cdots \\ 0\, 0\, 0\, 0 \cdots g_0 g_1 g_2 g_3 \end{pmatrix}.$$

The matrix representation is efficient solution to the implementation of wavelet transforms. In the case of the algorithm, operations are characterised by rotation and delay parameters. The complete algorithm of 128×128 pixels provides all possible multiresonlution time-spectral coefficients in internal DSP memory in 3.59 msec [4].

The only non-overlapping factor is to be changed. The algorithm structures are computationally efficient since, to calculate each coming block of multiresolution time-spectral coefficients. From the presented formulation we can see that the analysis structures based on the developed principle can provide an extremely effective way to extract the multiresolutional characteristics for frame synchronous processing systems.

4. Wavelet Transform Coding Error

The wavelet transform is one of the approaches for image data reduction. In two-dimensional wavelet transform an image is interpreted as a sum of details which appear at different resolutions. When considered to MPEG standard, where image is processed by discrete cosine transform, the wavelet transform is an serious alternative.

In wavelet transform based algorithms the coding error is distributed over the whole image without local phenomenon common for the most discrete cosine transform based algorithms [5]. The crucial property in wavelet transform based coding is correct use of the parts of image through the computation.

Several methods exists for compressing by wavelet transform images. Algorithms give image quality at small compression ratio. The sophisticated algorithms are based on block interpolation with mean values and slight modifications for better bit allocation for low dynamics sub-images.

5. Wavelet Transform Efficiency

The fast execution of wavelet transform is necessary to meet real-time requirements. The efficiency of the DSP algorithm can be measured by total number of arithmetic computations needed for its implementation [6].

On the available digital signal processor TMS320C50, it is possible to launch execution of more then one arithmetic operations in parallel. Therefore, the execution speed of an algorithm on the DSP is determined by a number of instructions required to implement the algorithm on the DSP, and not on a total number of arithmetic operations involved in its implementation [7].

6. Conclusions

The short wavelets, such as Daubechies' wavelets more efficient implementations can be reduced the computational complexity. Wavelet transform implementation has its advantage in using of parallel instruction set available on TMS320C50.

The data access capability and control instructions efficiency play the important role on the execution of DSP wavelet transform algorithms implementation. The method of image compression is proposed for its simple and effective way of image compression allowing simple and cheap hardware implementation. It is expected the further improvement of efficiency from image decomposition.

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