DSP IMPLEMENTATION OF EMBEDDED CODING FOR WAVELET BASED IMAGE COMPRESSION ON THE TMS320C6713

by

ISKANDAR ZULKARNAIN BIN SHAMSUDIN

(1432321172)

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School of Computer and Communication Engineering

UNIVERSITI MALAYSIA PERLIS MALAYSIA

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ABSTRAK

Sebagai kaedah mampatan standard baru untuk JPEG 2000, pengubah wavelet diskret (DWT) dengan cepat mencari lebih banyak kegunaan dalam jabatan mampatan imej. Dengan pengiraan yang banyak dan berulang-ulang diperlukan untuk mencari pekali imej yang besar, kelajuan adalah penting apabila melaksanakan sebuah bank penapis untuk mewakili DWT dalam perkakasan. Objektif tesis ini adalah untuk melaksanakan Coding Embedded Wavelet berdasarkan pemampatan gambar ke atas TMS320C6713. Ini kerana pelaksanaan masa untuk pengekodan yang tertanam pada komputer adalah mengambil lebih banyak masa untuk satu gambar. TMS320C6713 adalah papan terbenam yang menyediakan pelaksanaan masa lebih cepat supaya kod terbenam boleh memproses lebih cepat daripada komputer.

DSP Implementation of Embedded Coding for Wavelet Based Image Compression On The TMS320C6713

ABSTRAK

As the new standard compression method for the JPEG 2000, the discrete wavelet transform (DWT) is quickly finding more and more uses in the image compression department. With the numerous and repetitive calculations needed to find the coefficients of a large image, speed is critical when implementing a wavelet filter bank to represent the DWT in hardware. The objective o f this thesis is to implement a Embedded Coding for Wavelet Based Image Compression on the TMS320C6713. The reason of this because of the time execution for the embedded coding on computer is take more time to compress one image. TMS320C6713 is a embedded board that provide more fast time execution so that the embedded code can process more fast than the computer.

CHAPTER 1

INTRODUCTION

1.1 Background

There are two popular technique that people use when need to compress image. It is discrete wavelete transform (DWT) and discrete cosine transform (DCT) (Xiong, 1996). When first introduced of DWT, the number of uses increasing in many applications such as image and speech processing application as compression and enchancement image. In particular, wavelet image compression has proven to be most popular these day, not like the DCT, it does not have to be broken into "blocks" for the input image. That's why no wonder the DWT are mostly use than DCT as the JPEG 2000 standard (Taubman and Marcellin, 2002) because of the other advantages of DWT.

The transform coefficients are well compressed by using various codec algorithms like Embedded Zero-tree Wavelet (EZW) (Shapiro, 1993), Set Partitioning In Hierarchical Trees (SPHIT) (Said and Pearlman, 1996), Set Partitioning in Embedded Block (SPECK) (Pearlman et al, 2004), and Embedded Block Coding with Optimized Truncation (EBCOT) (Taubman, 2000) are the most famous ones. Computationally simple and effective techniques of transforming base image coding have been actualized by using significance and a set partitioning testing on transforming images of hierarchical structures. The algorithms of SPIHT and EZW are zero-tree based and its coefficients structured based by structure of zero-tree. SPIHT also uses spatial orientation tree in order to increase its efficiency of coding. EBCOT (Munteanu, A. et al, 1999) provides the highly improved compression rate among all. The concept of EBCOT is also adopted by JPEG2000 compression standard.

SPECK is contrast from EZW and SPHIT because of the wavelet coefficient organization and sets of partitioning which not use tree structure. The main objective is to achieve better energy compaction in frequency as well as in space in hierarchical structures of transforming images which can be achieved effectively using coding methods based on the use of block/sets. It is a known fact that statistics of an image transform, vary markedly as one move from one spatial region to another and by grouping transform source samples in the form of blocks and coding those blocks independently, one is able to exploit the statistics of each block in an appropriate manner (Zhang Yan, 2010). Image coding scheme on SPECK has all the attributes suitable in advanced image compression systems. The proposed scheme has also same properties which are as follows:

- It is totally embedded,
- It employs continuous transmission,
- It has low calculation complexity,
- It has low dynamic memory requirements,
- It is fast encoding/decoding,
- It is efficient in compression ratios for the wide range.

1.2 Problem Statement

Today's digital world deals with huge amount of digial data (audio, image and video). Despite the rapid progress in system performance, processor speed and mass storage density, demand for greater digital data storage capacity and transmission bandwidth is overwhelming. Data compression, particularly image compression plays a very vital role in the field of multimedia computer services and other telecommunication applications. Wavelet based techniques are the latest development in the field of image compression which offers multiresolution capability leading to superior energy compaction with high quality reconstructed images at high compression ratios. SPECK is one of the popular scheme and have more advantages and easy to implemented.

1.3 Aim and Objective

The aim of this research is to implement the embedded block on floating point DSP TMS320C6713. The objectives of the research are:

1. To study set-partitioning embedded block for 2D image compression.
2. To implement the embedded code for DSP TMS320C6713.
3. To compare the performance between simulation on MATLAB and DSP TMS320C6713.

1.4 Brief Methods

To implement SPECK in real time, it needs a platform to execute shifts, addition, and multiplication with powerful processing capabilities. The Texas Instruments (TI) floating -point processor TMS320C6713 based Digital Signal Processing Starter Kit (DSK) is one of the digital signal processing (DSP) chips suitable for the job.

The TMS320C6713 is a fast processor uses velocity architecture. It is a 32-bit floating processor. Also, it is a low-cost stand alone development platform to enable users to evaluate and develop applications for the TI C67xx DSP family. It has the following key features:

- It operates at 225MHz and sampling rate can be varied from 8 to 96KHz,
- It includes an AIC23 stereo codec which uses sigma delta technology and provides A/D and D/A,
- Synchronous DRAM is about 16 Mbytes,
- Non volatile Flash memory is about 512 bytes and in default configuration, 256 KBytes are usable,
- Four user accessible DIP switches and LEDs,
- Use of daughter card through standard expansion connectors,
- JTAG emulation through on board JTAG emulator with USB host,
- External emulator and interface,
- +5V single power supply.

With performance rating of 1800 million instructions per second (MIPs), it has very good speed to calculate the wavelet filtering coefficients in resoanable amount of time. The C6713 DSK allows to download and step through code quickly and uses Real Time Data Exchange (RTDX) for improved Host and Target communications.

For this work, the C6713 DSK has been used to implement SPECK alghorithm. A 512x512 scale image was used as the experimental input and the output send out to the MATLAB 7.0 to analyze the performance. In order to implement code to represent the SPECK, the functions was written in C code. C code was choosen because of the high powered C compiler already included with the Code Composer Studio so, no need to use assembly programming, which development time will be short.

The program code was compiled using the Code Composer Studio Version 3, specially made for TI's DSP chips. An output file was generated from all the necessary compiled files, which then loaded onto the SDRAM program memory. From here, the program was tested to see if it truly functions as it should and how well the results of the wavelet decomposition turn out. The results will be compared using Mean Square Error (MSE) and the Peak Signal to Noise Ratio (PSNR). The results from the Code Composer Studio (CCS) are then send out through RTDX to the MATLAB.

1.5 Scope of Research

In this research, there are many coding of wavelet coefficients. It has been grouped into tree-based and block based, according to the coefficient structure that is used. The block based is being used in this research.

The SPECK image coding scheme has all the properties that characterizes the scalar quantized significance testing schemes. It characteristic of SPECK as below:

- Completely embedded: A certain coded bit stream can be used to decode the image at any rate less than equal to the coded rate. It gives the finest reconstruction possible with the particular coding scheme.
- Employs progressive transmission: Source samples ae encoded in decreasing order of their information content.

- Low computational complexity: The algorithm is very simple and does not require any complex computation.
- Fast encoding/decoding: due to the low computational complexity of the algorithm.
- Low dynamic memory requirements: During the coding process , at any given time, only one connected region, lying completely within a subband is processed. After processing this region, the next region is considered for processing.
- High efficiency: Its performance is comparable to the other low complexity algorithms available today,

As per above characteristic, the SPECK algorithm was choosen for this work. Figure 1.1 shows the algorithms that has been used for the wavelet coefficient and the bold line is where the SPECK location.

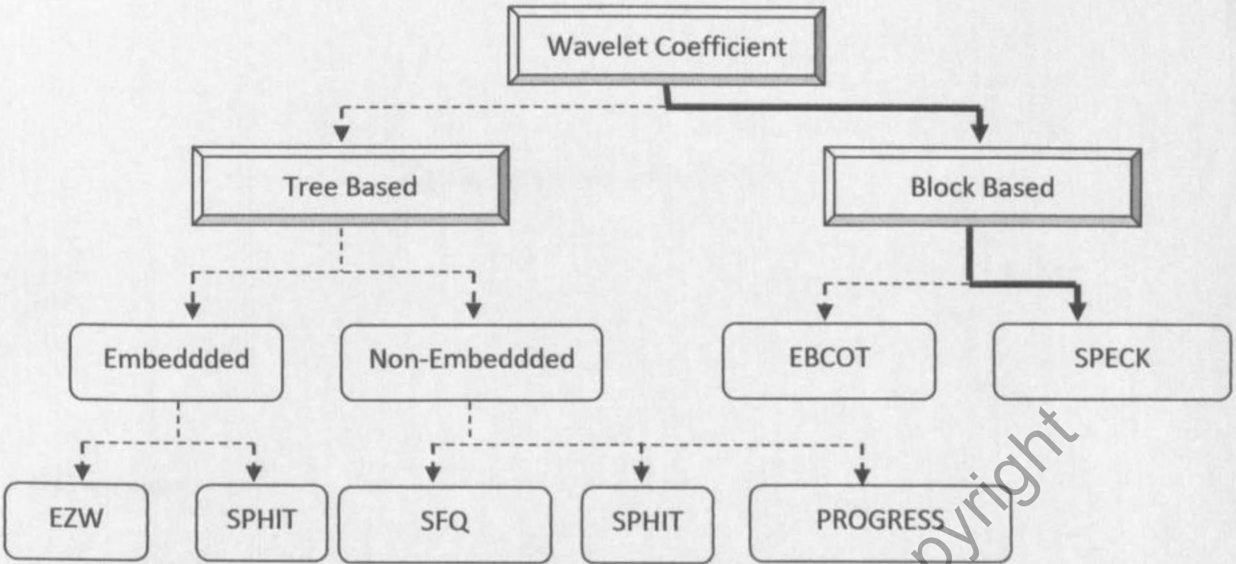

Figure 1.1: Scope of Research

1.6 Thesis Overview

The remains of the thesis is formed into four different chapters. For chapter 2, the summary of the refrred works done in the research is given. Chapter 3 defines the description of the proposed modification and implementation details. Chapter 4 shows the experimental results received using the coding alghorithm. Chapter 5 concludes the research findings with the recommendation of future work.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

This chapter reviews four main research scopes. First scope gives a general description of image compression, including the principles involved and basic parts. Secondly, starts an analysis of wavelets, the wavelet transform, and how the wavelet transform is used in sub-band decomposition. Thirdly, defines the Set Partitioning in Embedded Block (SPECK) and how the process works. Lastly provides a little glance into the TMS320C6713 DSK, which is the hardware on which the picture compression system will work.

2.2 Principles of Compression

Most image coders take advantage of different image features to specify what information to preserve and what information to leave out. Two of the characteristics used by most coders are redundancy and irrelevancy reduction. Redundancy reduction looks to eliminate repeating image pixel values at the coefficient level, such as zeros. In order to determine whether information is redundant or not, some type of correlation between pixels must exist. The two most coders are concerned with:

- Spatial redundancy, or correlation between neighboring pixels
- Spectral redundancy, or correlation between different spectral bands

Irrelevant reduction looks to get rid of image information that would not touch on how the human eye would see it. The human visual system (HVS) has a limited frequency range it can detect, usually the lower frequencies of an image. As a result, the higher frequencies of an image can usually be eliminated all together without worrying about detecting noticeable differences. With the use of these two reduction techniques, coders are able to lower the amount of image information to retain. Depending on the coding algorithm used, the amount of compression and the quality of the image varies.

When images are compressed for transmission, they can be kept in one of two forms: lossy or lossless format. Most users do have a limited amount of storage and bandwidth available for use, making lossy compression the more commonly used method of the two. Unlike lossless, lossy compression removes detail information from the image during compression, allowing a higher compression rate. Depending on the compression algorithm used, the human eye cannot visually notice the difference between the original and lossy image.

2.2.1 General Image Coder Parts

The typical lossy image coding system is broken up into two halves, with each half containing three parts. The two halves of the system are:

- Encoding sequence, which takes the original image and compresses it for transmission
- Decoding sequence, which takes the compressed image signal and reconstructs the image

As mentioned, each sequence is made up of three parts. The three parts of the encoder consist of the source encoder, quantizer, and entropy encoder. The general encoding sequence is shown below in Figure 2.1.

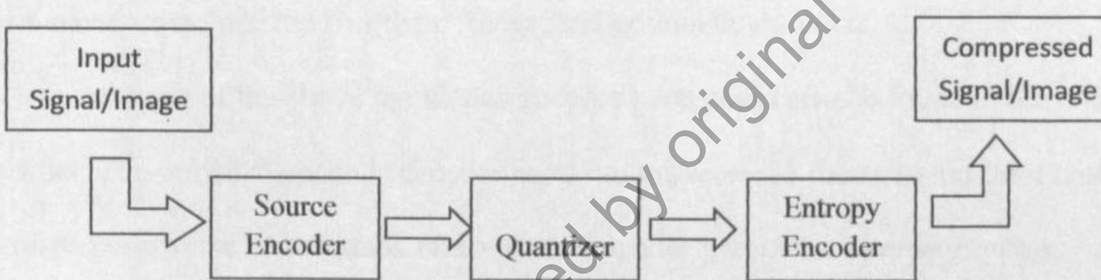

Figure 2.1: General Image Encoder

The first part of the image encoder is called the source encoder, or linear transformer. It is here where the original image will be run through a linear transform to de-correlate the image data. Differing methods utilize differing transforms, such as the Discrete Fourier Transform (DFT), Discrete Cosine Transform (DCT), and the Discrete Wavelet Transform (DWT). For this thesis, the DWT with perfect reconstruction filters (lossless) will be used.

The second part of the image encoder is the quantizer. This is the stage where actual compression will take place, using the previously mentioned redundancies to remove information. It is here where the transformed image coefficients from the source encoder are taken and adjusted in value in order to reduce the number of bits needed to store or transmit.

Many different quantization algorithms have been created over the years. Some can be used on coefficients from any source encoder while others apply specifically to one type of the encoder. The SPECK coder is one of these wavelet transform specific encoders and is the one utilized for this thesis.

The final piece of an image encoder is the entropy encoder. Entropy encoders use a coding scheme to assign codes to symbols so as to match the code lengths with the probabilities of the symbols ("Entropy Encoding," n.d.). Some of the more commonly used encoders include the Huffman, Range, and arithmetic encoders.

All three of the above mentioned encoder parts could also be found in the image decoder. The only difference is decoder parts run the received transmission information through the inverse of the steps taken at the encoder parts, in a reverse process. As a result, transmission information at the decoder will first enter the entropy decoder, followed with the de-quantizer, and ending with the source decoder. It is here at the source decoder that the final reconstructed image will emerge.

2.3 The Wavelet and Wavelet Transform Definition

A signal or function f(t) can often be better analyzed, described, or processed if expressed as a linear decomposition by

$$f(t) = \sum_{\ell} \alpha_{\ell} \varphi_{\ell}(t) \tag{2.1}$$

where ℓ is an integer index for the finite or infinite sum, α_ℓ are the real-valued expansion coefficients, and $\varphi_\ell(t)$ are a set of real-valued functions of t called the expansion set. If the expansion (2.1) is unique, the set is called a basis for the class of functions that can be so expressed. If the basis is orthogonal, meaning

$$\langle\varphi_k(t),\varphi_\ell(t)\rangle = \int \varphi_k(t)\varphi_\ell(t)\,\mathrm{dt} = 0 \qquad k \neq \ell, \qquad (2.2)$$

Then the coefficients can be calculated by the inner product

$$\alpha_k = \langle f(t),\varphi_k(t)\rangle = \int f(t)\varphi_k(t)\,dt. \qquad (2.3)$$

One can see that substituting (2.1) into (2.3) and using (2.2) gives the single α_k coefficient. If the basis set is not orthogonal, then a dual basis set $\varphi_k(t)$ exists such that using (2.3) with the dual basis gives the disered coefficients.

For the wavelet expansion, a two parameter system is constructed such that (2.1) becomes

$$f(t) = \sum_k \sum_j \alpha_{j,k}\varphi_{j,k}(t) \qquad (2.4)$$

Where both j and k are integer indices and the $\varphi_{j,k}(t)$ are the wavelet expansion functions that usually form an orthogonal basis.

The set of expansion coefficients $\alpha_{j,k}$ are called the discrete wavelet transform (DWT) of $f(t)$ and (2.4) is the inverse transform. Example of some wavelets are given in Figure 2.2. Wavelet are used as basis functions in representing other functions sometimes called the mother wavelet.

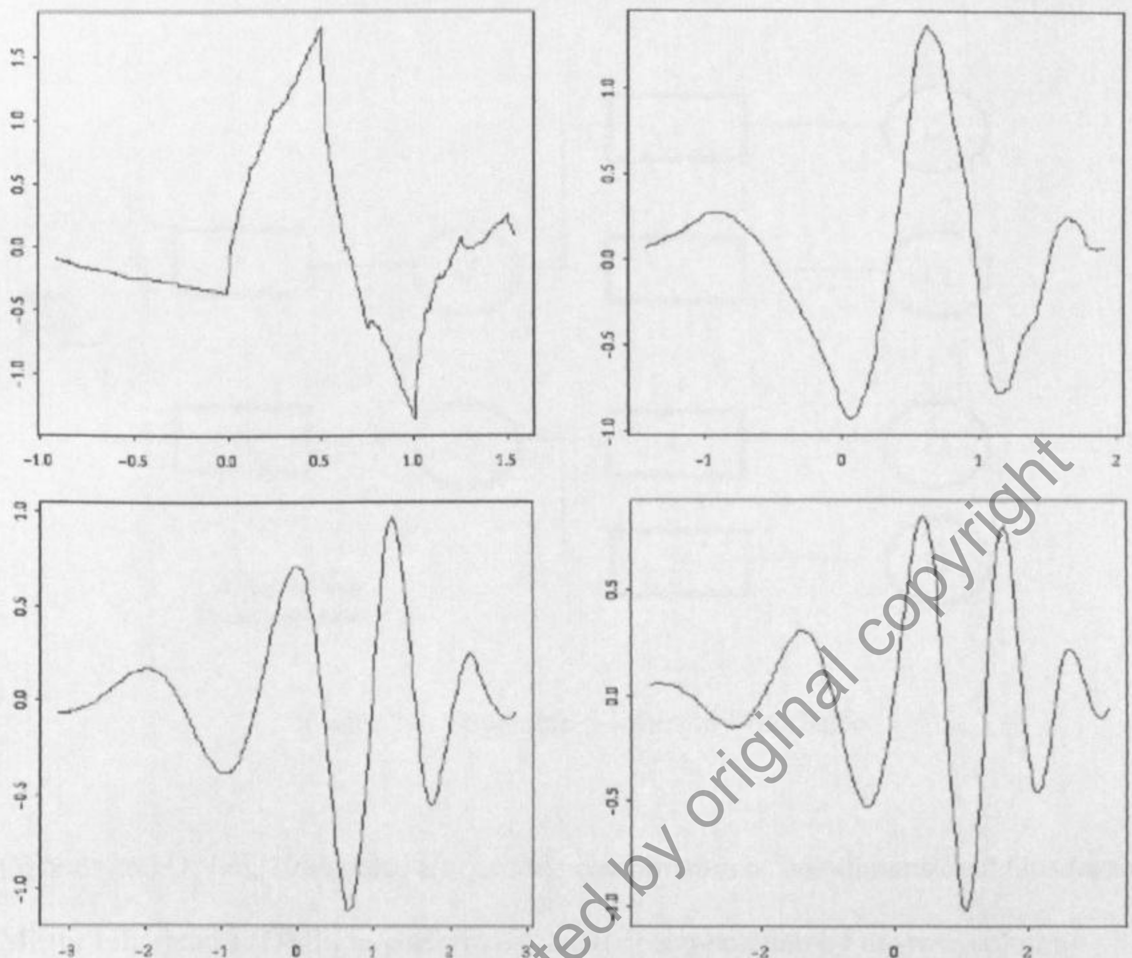

Figure 2.2: Wavelets

2.3.1 Wavelet Sub-band Coding

The fundamental concept behind Subband Coding (SBC) is to split up the frequency band of a signal (image in our case) and then to code each subband using a coder and bit rate accurately matched to the statistics of the band. SBC has been used extensively first in speech coding (Estaban and Galand, 1977) and later in image coding (Woods and O'Neil, 1986) because of its inherent advantages namely variable bit assignment among the subbands as well as coding error confinement within the subbands.