ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 8, August 2015

An Implementation of Efficient Low Power VLSI Architecture for Image Compression System Using DCT and IDCT"

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ABSTRACT: Image compression is an important topic in digital world. It is the art of representing the information in a compact form. This project deals with the implementation of low power VLSI architecture for image compression system using DCT. Discrete Cosine Transform (DCT) constitutes a powerful tool in signal processing; the discrete cosine transform (DCT) is a technique for converting a signal into elementary frequency components. Discrete Cosine Transform (DCT) is the most widely used technique for image compression of JPEG images and is a lossy compression method.

DCT is computationally more intensive since it takes on large number of multiplications. There are many algorithms for DCT has been proposed to reduce the number of computations and hence the power. In this project architecture of DCT is based on Lo-effler method, which is a fast and low complexity algorithm. In the proposed architecture of DCT multipliers are replaced with adders and shifters. And other two approaches are carried out, those are Low power approaches like Canonic signed digit representation for constant coefficients and sub-expression elimination methods have been used. The 2D DCT is performed on 8x8 image matrix using two 1D DCT blocks and a transposition block. Similar to DCT, the IDCT is also implemented using the Lo-effler algorithm for IDCT. Verilog HDL is used to implement the design. ISIM of XILINX is used for the simulation of the design **.**Finally results are verified on FPGA board.

KEYWORDS*:* Intel Pentium IV , 1 GB RAM, FPGA kit, Windows XP SP-3 or Windows 7, Xilinx ISE Simulator

I.INTRODUCTION

Image compression, the art and science of reducing the amount of data required to represent an image, is one of the most useful and commercially successful technologies in the field of digital image processing. Image data compression is the technique to reduce the redundancies in the image data representation in order to decrease the data storage requirement and hence the communication cost. Reducing the storage requirement is equivalent to increasing the capacity of storage medium and hence communication bandwidth. Thus the development of efficient compression techniques will continue to be a design challenge for future communication system and advanced media application. Image compression plays an important role in many areas of interest like tele-video conferencing, remote sensing, document and medical imaging. An increasing number of applications depend on efficient manipulation, storage, and transmission of binary, gray scale and color image.

Image compression algorithms can be broadly classified into lossy compression and lossless compression. The JPEG is one of the most popular and comprehensive continuous tone, still frame compression standard which is centered on DCT. The DCT transforms the input image which is split into non-overlapping blocks of 8x8 matrix in spatial domain into frequency domain with different frequencies. DCT is computationally intensive since it takes on large number of multiplications. Many algorithms for DCT has been proposed to reduce the number of computations and hence the power. It is also been proved that the lower bound of multiplications for the computation of DCT is 11. In this project for DCT is implemented using Lo-effler algorithm which requires 11 multiplications and 29 additions. This algorithm was selected as it uses minimum number of mathematical operations. In the design Canonic Signed Digit (CSD) representation for the constant coefficients is used which again reduces the effort of multiplications. Also

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the multipliers are replaced with adders and shifters. A technique known as Common Sub-expression Elimination is used so as to obtain the utilization of the resources. Hence, all of these make the design a low power implementation.

The aim of this paper is to study and design low power VLSI architecture of DCT and IDCT for image compression. As well as study and implementation of Lo-effler algorithm and the other two approaches are Canonic Signed Digit (CSD) and Common Sub expression Elimination (CSE), which are mainly used for ensures the low power.

II.IMAGE COMPRESSION AND RECONSTRUCTION

Image compression is the application of data compression on digital images. In effect, the objective is to reduce redundancy of the image data in order to be able to store or transmit data in an efficient form. A common characteristic of most images is that their neighboring pixels are correlated and therefore contain redundant information. The foremost task is to find less correlated representation of the image. Two fundamental components of compression are redundancyand irrelevancy reduction. Redundancy reduction aims at removing duplication from the signal source (image/video). Irrelevancy reduction omits parts of the signal that will not be noticed by the signal receiver, namely the Human Visual System. Image compression research aims at reducing the number of bits needed to represent an image by removing the spatial and spectral redundancies as much as possible. The spatial and spectral redundancies are present because certain spatial and spectral patterns between the pixels and the color components are common to each other, whereas the psycho-visual redundancy originates from the fact that the human eye is insensitive to certain spatial frequencies.

The principle of image compression algorithms are (i) reducing the redundancy in the image data and (or) (ii) producing a reconstructed image from the original image with the introduction of error that is insignificant to the intended applications. The aim here is to obtain an acceptable representation of digital image while preserving the essential information contained in that particular data set.The decompression reverses the compression process to produce the recovered image The recovered image may have lost some information due to the compression, and may have an error or distortion compared to the original image.

III.TYPES OF IMAGE COMPRESSION

There are two types of image file compression algorithms: 1. Lossy 2. Lossless

Lossy Image Compression:A lossy data compression method is one where compressing data and then decompressing it retrieves data that may well be different from the original, but is "close enough" to be useful in some way. Lossy data compression is most commonly used to compress multimedia data (audio, video, still images) especially in applications, such as streaming media and internet telephony Inlossy compression the decompressed information is different from the original uncompressed information. Lossless compression is also known as *irreversible compression.* Lossy image compression is mostly suitable for continuous media such as sound and video as well as for many images In lossy compression the decompressed information is different from the original uncompressed information. Lossless compression is also known as *irreversible compression.* Lossy image compression is mostly suitable for continuous media such as sound and video as well as for many images. Most lossy data compression formats suffer from generation loss: repeatedly compressing and decompressing the file will cause it to progressively lose quality. There are two basic lossy compression schemes.

In lossy transform codecs, samples of picture or sound are taken, chopped into small segments, transformed into a new basis space, and quantized. The resulting quantized values are then entropy coded. In lossy predictive codes, previous and/or subsequent decoded data is used to predict the current sound sample or image frame. The error between the predicted data and the real data, together with any extra information needed to reproduce the prediction, is then quantized and coded. In some systems the two techniques are combined, with transform codecs being used to compress the error signals generated by the predictive stage.

Lossless Image Compression: Lossless data compression is a class of data compression algorithms that allows the exact original data to be reconstructed from the compressed data. This can be contrasted to lossy data compression,

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which does not allow the exact original data to be reconstructed from the compressed data. Lossless compression is used when it is important that the original and the decompressed data be identical, or when no assumption can be made on whether certain deviation is uncritical. The information is recovered without any alteration after the decompression process. The information contained in the compression bit stream is identical to the information contained in the original source bit stream.

Lossless compression is also called *reversible compression* or *bit-preserving compression* Most lossless compression programs use two different kinds of algorithms: one which generates a statistical model for the input data, and another which maps the input data to bit strings using this model in such a way that "probable" (e.g. frequently encountered) data will produce shorter output than "improbable" data. Often, only the former algorithm is named, while the latter is implied (through common use, standardization etc.) or unspecified. Lossless image compression coding techniques include: Huffman coding, fano coding and run length coding. Lossless data compression is used in many applications. For example, it is used in the popular ZIP file format. It is also often used as a component within lossy data compression technologies. Typical examples are executable programs and source code. Image file formats, like PNG or GIF, use only lossless compression

IV. IMAGE COMPRESSION USING DCT

The discovery of the Discrete Cosine Transform (DCT) in 1974 is an important achievement for the research community working on image compression. The Discrete Cosine Transform possess some fine properties, i.e., de-correlation, energy compaction, separability, symmetry and orthogonality, due to which it is virtually used in every image/video processing standard such as signal and image processing and especially for lossy data compression because it has a strong "energy compaction" property: most of the signal information tends to be concentrated in a few low-frequency components of the DCT and high-frequency components are eliminated, approaching the *Karhunen-Loève Transform* (KLT) for signals based on certain limits of Markov processes. Compression standards like JPEG, for compression of still images, MPEG, for compression of motion video, MP3, for compression of audio streams and the H.263, for compression of video telephony and teleconferencing all employ the basic technique of the DCT.

Discrete cosine transform (DCT) is widely used in image processing, especially for compression. Some of the applications of two-dimensional DCT involve still image compression and compression of individual video frames, while multidimensional DCT is mostly used for compression of video streams. DCT is also useful for transferring multidimensional data to frequency domain, where different operations, like spread spectrum, data compression, data watermarking, can be performed in easier and more efficient manner. A number of papers discussing DCT algorithm is available in the literature that signifies its importance and application.

Hardware implementation of parallel DCT transform is possible, that would give higher throughput than software solutions. Special purpose DCT hardware decreases the computational load from the processor and therefore improves the performance of complete multimedia system. The throughput is directly influencing the quality of experience of multimedia content. Another important factor that influences the quality is the finite register length effect that affects the accuracy of the forward-inverse transformation process.

Hence, the motivation for investigating hardware specific DCT algorithms is clear. As 2-D DCT algorithms are the most typical for image compression, the main focus of this chapter will be on the efficient hardware implementations of 2-D DCT based compression by decreasing the number of computations, increasing the accuracy of reconstruction, and reducing the chip area. This in return reduces the power consumption of the compression technique. As the number of applications that require higher-dimensional DCT algorithms are growing, a special attention will be paid to the algorithms that are easily extensible to higher dimensional cases.

The JPEG standard has been around since the late 1980's and has been an effective first solution to the standardization of image compression. Although JPEG has some very useful strategies for DCT quantization and compression, it was only developed for low compressions. The 8×8 DCT block size was chosen for speed (which is less of an issue now, with the advent of faster processors) not for performance. The JPEG standard will be briefly explained in this chapter to provide a basis to understand the new DCT related work.

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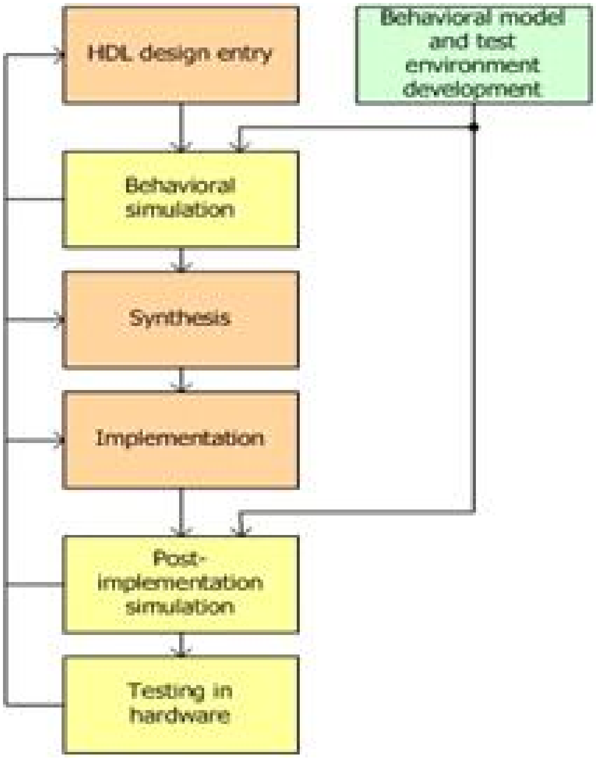
APPLICATIONS OF DCT: The DCT has a number of applications in information theory. DCT is widely used in JPEG image compression, MJPEG, MPEG, and DV video compression. DCTs are widely employed in solving partial differential equations by spectral methods, where the different variants of the DCT correspond to slightly different even/odd boundary conditions at the two ends of the array. DCT"s are also closely related to Chebyshev polynomials, and fast DCT algorithms are used in Chebyshev approximation of arbitrary functions by series of Chebyshev polynomials, for example in Clenshaw-Curtis quadrature

V. FPGA IMPLEMENTATION

FPGA Implementation is done using Xilinx ISE EDA tool. FPGA design involves writing HDL (hardware description language) code, creating test benches (test environments), synthesis, implementation and debugging. A brief overview is as shown in Fig.



HDL design entity is a class of high-level languages which is used to define how the device should work. It can be thought about as a programming language, though significantly different from the conventional programming languages. The most frequently used hardware description languages are VHDL and Verilog.
Behavioral simulation is used to verify the HDL description against the correspondingbehavioral model (using test environment). Most design errors are fixed at this stage.
Synthesis is an automated process of converting a high-level HDL description to amachine-readable circuit description (a so-called *netlist*). Although synthesis of a correctly written HDL code shouldn't be a problem, some errors uncaught by behavioral simulation can appear at this stage.
Implementation is a process of converting netlist to an FPGA configuration bit stream.
Post-implementation simulation is used to verify the implemented design (takingswitching and propagation delays into account) against the behavioral model. This step can be omitted for simple designs. And finally, testing a produced bit stream in hardware. The simulation, synthesis and implementation will be discussed in this chapter. The Verilog code developed for this project. The design is synthesized using Xilinx ISE and implemented on FPGA board.

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VI. SYNTHESIS USING XILINX TOOL

Synthesis is the transformation of design from higher level of abstraction to lower level of abstraction .The project is carried out on FPGA development kit.Afterwards we comparing the results of simulation with the FPGA board, then we verified that both the results are same

VII. EXPERIMENTAL SETUP

The FPGA implementation is interfaced with the computer via a JTAG USB port. The generated programming file is dumped via this JTAG USB port. Once the top module code is synthesized, its design is implemented on the specified device. FPGA board is interfaced with the computer in which the top module code is synthesized and implemented. The Experimental Setup is as shown in Fig.

Once the interfacing is done, the corresponding programming file for the top module is generated. The target device is then configured so that the generated programming file can be successfully dumped as shown in Figure. The Chip Scope output is observed. The Chip Scope output is successfully compared with Xilinx ISE‟s simulation output.

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VIII. CONCLUSION AND FUTURE WORK

Image compression is of prime importance in Real time applications like video conferencing where data are transmitted through a channel. Using JPEG standard DCT is used for mapping which reduces the interpixel redundancies followed by quantization which reduces the psycho visual redundancies then coding redundancy is reduced by the use of optimal code word having minimum average length.In JPEG 2000 standard of image compression DWT is used for mapping, all other methods remaining same.DWT is more general and efficient than DCT due to the following result:-

No need to divide the input coding into non-overlapping 2-D blocks, it has higher Compression ratios avoid blocking artifacts. Allows good localization both in time and spatial frequency domain Transformation of the whole image_ introduces inherent scaling Better identification of which data is relevant to human perception_ higher compression ratio In VLSI mainly we focusing on three parameters like area, size and power so in future we can develop the multiple point DCT algorithms(i.e. Lo-Effler algorithm) like 16 or 32 etc, so making use of this one we can increase the performance, as well area and power can be achieve effectively for any kind of images.

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ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 8, August 2015

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BIOGRAPHY

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