IMAGE PROCESSING USING DISCRETE WAVELET TRANSFORM

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ABSTRACT

The quality and the size of image data is constantly increasing. With the advancement in technology, many products in the market use images for control and display. Image compression is one of the primary image processing techniques that are embedded in all electronic products. Fast and optimally interactive post processing of these images is a major concern. E.g., reduce the redundancy of the image data in order to be able to store or transmit data in an efficient form is difficult task to be performed. This paper presents a framework for an Image processing -based Discrete Wavelet Transform system. The approach helps the end-user to generate images using DWT at a high level without any knowledge of the low-level design styles and architectures.

Keywords: - Discrete Wavelet Transform (DWT), image processing.

1. INTRODUCTION

Image compression is one of the most promising subjects in image processing. Images captured need to be stored or transmitted over long distances. Raw image occupies memory and hence need to be compressed. With the demand for high quality video on mobile platforms there is a need to compress raw images and reproduce the images without any degradation. Several standards such as JPEG200, MPEG-2/4 recommend use of Discrete Wavelet Transforms (DWT) for image transformation which leads to compression with when encoded. Wavelets are a mathematical tool for hierarchically decomposing functions in multiple hierarchical sub bands with time scale resolutions. Image compression using Wavelet Transforms is a powerful method that is preferred by scientists to get the compressed images at higher compression ratios with higher PSNR values. It is a popular transform used for some of the image compression standards in lossy compression methods. Unlike the discrete cosine transform, the wavelet transform is not Fourier-based and therefore wavelets do a better job of handling discontinuities in data. The Discrete Wavelet Transform (DWT) is an efficient and useful tool for signal and image processing applications and will be adopted in many emerging standards, starting with the new compression standard JPEG2000. This growing “success” is due to the achievements reached in the field of mathematics, to its multiresolution processing capabilities, and also to the wide range of filters that can be provided. These features allow the DWT to be tailored to suit a wide range of applications. In the early 80s, in the quest for more flexibility and rapid prototyping at low cost, custom logic based re-configurable hardware in the form of Field Programmable Gate Arrays (FPGAs) has been introduced into the IC market. However, although the fact FPGA devices offer an attractive combination of low cost, high performance, and apparent flexibility, their programming model is at the gate level. To allow an FPGA novice signal/image processing developer to benefit from the advantages offered by such devices, high level solutions are desired. It is the aim of this paper to present a framework and the preliminary results of an FPGA-based Discrete Wavelet Transforms system. The proposed environment is a Java-based Graphical User Interface (GUI) combined with both a wavelet database and a parameterized VHDL code generator. Due to the fact that DWT, unlike the Discrete Cosine Transform, is not unique, the filter template needs to be provided for each application with the parameters of the DWT (type, number of coefficients, 2’s complement values...).

Methods for compression
There are two methods for compression.
1. Discrete Cosine Transform (DCT)
2. Discrete Wavelet Transform (DWT)
2. METHODOLOGY

2.1 DCT for image processing

The DWT represents the signal in dynamic sub-band decomposition. Generation of the DWT in a wavelet packet allows sub-band analysis without the constraint of dynamic decomposition. The discrete wavelet packet transform (DWPT) performs an adaptive decomposition of frequency axis. The specific decomposition will be selected according to an optimization criterion. The Discrete Wavelet Transform (DWT), based on time-scale representation, provides efficient multi-resolution sub-band decomposition of signals. It has become a powerful tool for signal processing and finds numerous applications in various fields such as audio compression, pattern recognition, texture discrimination, computer graphics etc. Specifically the 2-D DWT and its counterpart 2-D Inverse DWT (IDWT) play a significant role in many image/video coding applications. Using this image processing the size and quality of image data can be reduced, so that it can be stored in a small amount of memory. In this the image is compressed and decompressed and the results have been given at the output.

2.2 DWT for image processing

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![Image Processing Block Diagram](image1.png)

**Figure 1** block diagram of Image processing

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![DWT Decomposition](image2.png)

**Figure 2** DWT Decomposition

The DWT architecture, the input image is decomposed into high pass and low pass components using HPF and LPF filters giving rise to the first level of hierarchy. The process is continued until multiple hierarchies are obtained. A1 and D1 are the approximation and detail filters.
The barbara image is first decomposed into four sub bands of LL, LH, HL and HH. Further the LL sub band is decomposed into four more sub bands as shown in the figure. The LL component has the maximum information content as shown, the other higher order sub bands contain the edges in the vertical, horizontal and diagonal directions. An image of size N X N is decomposed to N/2 X N/2 of four sub bands. Choosing the LL sub band and rejecting the other sub bands at the first level compresses the image by 75%. Thus DWT assists in compression. Further encoding increases compression ratio.

![Figure 3](image.png)

2.3 Technologies

Image compression techniques are used to reduce redundancy in video data without affecting visual quality. It mostly used in video conference and real time application.

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In this paper DCT (Discrete Cosine transform) and DWT (Discrete Wavelet Transform) are used for image compression. Here DWT will perform the adaptive filtering and DCT will use these weighted values as DCT coefficient. We apply DCT and DWT techniques are applied to check the performance, based on compression ratio is analyzed.

2.3.1 DCT (Discrete Cosine Transform)
A discrete cosine transform (DCT) express a sequence of many data points in terms of a sum of cosine functions at different frequencies. DCTs are important to lossy compression of audio (e.g. MP3) and images (e.g. JPEG).

Disadvantages of DCT.
- Only spatial correlation of the pixels inside the single 2-D block is considered and the correlation from the pixels of the neighboring blocks is neglected.
- Impossible to completely decorrelate the blocks at their boundaries using DCT
- Undesirable blocking artifacts affect the reconstructed images or video frames. (high compression ratios or very low bit rates.
- Poor identification of which data is relevant to human perception less compression ratio.

2.3.2 DWT (Discrete Wavelet Transform)
The Discrete Wavelet Transform (DWT) is an efficient and useful tool for signal and image processing applications and will be adopted in many emerging standards, starting with the new compression standard JPEG2000. This growing “success” is due to the achievements reached in the field of mathematics, to its multiresolution processing capabilities, and also to the wide range of filters that can be provided. These features allow the DWT to be tailored to suit a wide range of applications. In the early 80s, in the quest for more flexibility and rapid prototyping at low cost, custom logic based re-configurable hardware in the form of Field Programmable Gate Arrays (FPGAs) has been introduced into the IC market. However, although the fact FPGA devices offer an attractive combination of low cost, high performance, and apparent flexibility, their programming model is at the gate level. To allow an FPGA novice signal/image processing developer to benefit from the advantages offered by such devices, high level solutions are desired. It is the aim of this paper to present a framework and the preliminary results of an FPGA-based Discrete Wavelet Transforms system. The proposed environment is a Java-based Graphical User Interface (GUI) combined with...
both a wavelet database and a parameterized VHDL code generator. The Discrete Wavelet Transform passing a signal to image, through a pair of filters, a low pass filter and a high pass filter. The low pass filter yields low resolution signal. The high pass filter yields difference signal. The outputs of these filters are down sampled by two. The down sampled outputs have the same number of bits as the input signal. The original signal is reproduced, when the up sampled output of the low pass filter is added to the up sampled output of the high pass filter. The output of the high pass filter is fed into another pair of filters and the process repeated. Haar wavelet transform is the simple example of discrete wavelet transforms. The wavelet transform (WT) has gained widespread acceptance in signal processing and image compression. Because of their inherent multi-resolution nature, wavelet-coding schemes are especially suitable for applications where scalability and tolerable degradation are important. Recently the JPEG committee has released its new image coding standard, JPEG-2000, which has been based upon DWT. Discrete wavelet transform (DWT), which transforms a discrete time signal to a discrete wavelet representation.

3. RESULTS AND DISCUSSION

Most of the image compression techniques use DWT (Discrete wavelet Transform) based transformation for compression. DWT is used for image decomposition and an N x N image is decomposed using DWT into hierarchical blocks the decomposition is carried out until the sub block is of size 8 x 8. For a image of size 64 x 64, first level decomposition gives rise to 32 x 32 (four sub bands) of sub blocks, further decomposition leads to 16 x 16 (sixteen sub bands), which can further decamped to 8 x 8 at the third hierarchy. The third level of hierarchy there are 64 sub blocks each of size 8 x 8. Figure 4 shows the decomposition levels of input image of size 64 x 64 using 2D-DWT. The sub bands are further decomposed into four sub bands as shown in Figure 4.

![Figure 4](image_url)

**Figure 4** DWT result after two level decomposition

The image compression is done using the DWT. The decompressed image is reconstructed using IDWT.
The input image is decomposed into sub bands using DWT, the input image of size N x N is decomposed into 1-level (Shown in (b)), further the four sub bands is decomposed into 8 sub bands using DWT (Shown in (c)), the decomposed sub bands are reorganized into column matrix. The compressed image is further decompressed using the output layer (compressed output and decompressed output are not shown in the figure). The decompressed output from the output layer is rearranged and inverse DWT is performed (shown in (e)), the second level inverse DWT is performed and the final output is reconstructed to obtain the original image. In this proposed architecture, the input image is first decomposed into multiple sub blocks using hierarchical DWT architecture.

3.1 Applications

Some of the major fields in which digital image processing is widely used are mentioned below

- Image sharpening and restoration
- Medical field
- Remote sensing
- Transmission and encoding
- Machine/Robot vision
- Color processing
- Pattern recognition
- Video processing
- Microscopic Imaging
- Others

4. CONCLUSION

In this paper the methods for optimal computer aided designs of selected DWT based image compression techniques are carried out. The design is simulated in MATLAB and the software reference model is verified. The weights and biases obtained using the software environment is used in developing verilog model. The computation complexity of the DWT architecture can be further reduced by designing the subsystems, selection of appropriate data path operators and state machines for data flow logic.
REFERENCES