A survey on image compression Using 2D-DCT algorithms

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Abstract-This paper presents a study on image compression algorithms. The goal is to find the existing work in the field of image compression algorithms. Various high quality papers are selected for evaluation. The benefits and limits of the compression techniques also discussed in this paper. The overall objective is to find an analytical assumption that why lossy compression is useful and also how we can enhance it by using improved DCT compression.

I. INTRODUCTION

In recent years, the development and demand of multimedia product grows increasingly fast, contributing to insufficient bandwidth of network and storage of memory device. Therefore, the theory of data compression becomes more and more significant for reducing the data redundancy to save more hardware space and transmission bandwidth. In computer science and information theory, data compression or source coding is the process of encoding information using fewer bits or other information-bearing units than an uuencoded representation. Compression is useful because it helps reduce the consumption of expensive resources such as hard disk space or transmission bandwidth [1].

In digital image compression, three basic data redundancy can be identified and exploited: coding redundancy, interpixel redundancy and psych visual redundancy. Data compression is achieved when one or more of these redundancies are reduced or eliminated [2]. An image's file size can be reduced with or without a loss in quality of the image; these are called lossy compression and lossless compression, respectively. Image compression is useful when a computer user wishes to minimize required storage space or maximize data transfer rates of an image.

The first type of image compression is lossy compression. A user seeking to dramatically reduce an image file size may opt for a lossy compression method if some reduction in image quality is worth a significant reduction in file size. Pictures and videos from digital cameras are examples of digital files that are commonly compressed using lossy methods. A user will not be able to restore the original image because there will be compression artifacts, or irreversible alterations, in the image.

A simple method of lossy image compression is to reduce the color space to a smaller set of colors. Color spaces can range from only eight distinct colors to millions of colors. The larger the color space, the more data is required to specify a particular color. Converting an image to gray scale, or to shades of gray, is a similar lossy image compression technique.

Lossless image compression is any method of reducing an image's file size without sacrificing information about the image an identical image to the original can always be retrieved. Lossless forms of data compression are necessary when reductions in quality are deemed unacceptable. Medical imaging, technical drawings, and astronomical observations typically use lossless compression techniques.

One loseless image compression method is called run-length encoding. Often, simple images have many repetitive pixels, or small points of color. For example, in an image with a black background, the entire top row of pixels may be black. The run-length encoding method stores this string of black pixels in two values: one for the color and one for the number of pixels in the string. This method can store the same amount of information with much less data.

II. LITERATURE SURVEY

Priyanka Singh Tejyan and Priti Singh has studied a novel approach to 2d-dct & 2d-dwt based jpeg image compression [3]. Image compression using wavelet transforms results in an improved compression ratio. Wavelet transformation is the technique that provides both spatial and frequency domain information. These properties of wavelet transform greatly help in identification and selection of significant and non-significant coefficients amongst the wavelet coefficients. DWT (Discrete Wavelet Transform) represents image as a sum of wavelet function (wavelets) on different resolution levels. So, the basis of wavelet transform can be composed of function that satisfies requirements of multi resolution analysis. The choice of wavelet function for image compression depends on the image application and the content of image. A review of the fundamentals of image compression based on wavelet is given here.

Prashant Chaturvedi et al have been researched a novel VLSI based architecture for computation of 2D-DCT image compression [4]. Data image compression is the reduction of redundancy in data representation in order to achieve reduction in storage cost. The Implementation and Optimization of FPGA based 2DDCT (discrete Cosine Transform) with Quantization and Zigzag with parallel pipelining using VHDL. The two 1D-DCT Separability property and calculation by using a Transpose buffer.

Nageswara Rao Thota and Srinivasa Kumar Devireddy have studied the Image

Compression Using Discrete Cosine Transform [5]. Image compression is the application of data compression on digital images. Image compression can be lossy or lossless. In this paper it is being attempted to implement basic JPEG compression using only basic MATLAB functions. The lossy compression techniques have been used, where data loss cannot affect the image clarity in this area. Image compression addresses the problem of reducing the amount of data required to represent a digital image. It is also used for reducing the redundancy that is nothing but avoiding the duplicate data. It also reduces the storage area to load an image. For this purpose we are using JPEG. JPEG is a still frame compression standard, which is based on, the Discrete Cosine Transform and it is also adequate for most compression applications. The discrete cosine transform (DCT) is a mathematical function that transforms digital image data from the spatial domain to the frequency domain.

T. Pradeepthi and Addanki Purna Ramesh have researched pipelined architecture of 2D-DCT, quantization and zigzag process for jpeg image compression using VHDL [6]. The architecture and VHDL design of a Two Dimensional Discrete Cosine Transform (2D-DCT) with Quantization and zigzag arrangement. This architecture is used as the core and path in JPEG image compression hardware. The 2D- DCT calculation is made using the 2D- DCT Separability property, such that the whole architecture is divided into two 1D-DCT calculations by using a transpose buffer.

Abhishek Kaushik and Maneesha Gupta have studied on the analysis of image compression algorithms [7]. Image compression is the application of Data compression on digital images. The discrete cosine transform (DCT) is a technique for converting a signal into elementary frequency components. It is widely used in image compression. Here some simple functions developed to compute the DCT and to compress images. An image compression algorithm was comprehended using MATLAB code, and modified to perform better when implemented in hardware description language.

Vikrant Kumar has researched the design & implementation of 2D DCT/IDCT using XiLinx FPGA [8]. The design of two-dimensional discrete cosine transforms (DCT) architecture for Multimedia communication applications has described in it. It is basic transformation for coding method to transform the image formation from spatial domain to frequency domain in compact form. The main objective of proposed technique is to explore one of various architectures for optimizing any one or all of the given constraints (area, performance). Given these constraints (area, performance) our explored architecture will be a best suited as per the requirement. Above architecture is designed and implemented in VHDL and synthesis using Xilinx tools and implemented on FPGA.

Anitha S has studied the 2D image compression technique-a survey [9]. Advanced imaging requires storage of large quantities of digitized data. Due to the constrained bandwidth and storage capacity, images must be compressed before transmission and storage. However the compression will reduce the image fidelity, especially when the images are compressed at lower bitrates. The reconstructed images suffer from blocking artifacts and the image quality will be severely degraded under the circumstance of high compression ratios. Medical imaging poses the great challenge of having compression algorithms that reduce the loss of fidelity as much as possible so as not to contribute to diagnostic errors and yet have high compression rates for reduced storage and transmission time. To meet this challenge several hybrid compression schemes have been developed in the field of image processing. Various compression techniques based on DCT, DWT, ROI and Neural Networks for two dimensional (2D) images.

P. Subramanian has described the VLSI implementation of fully pipelined multiplierless 2D DCT/IDCT architecture for JPEG [10]. The Discrete Cosine transform is widely used as the core of digital image compression. Discrete cosine transforms attempts to de-correlate the image data. After decor relation, each transform coefficient can be encoded independently without losing compression efficiency.

H. Anas has studied FPGA implementation of a pipelined 2D-DCT and simplified quantization for real-time applications [11]. The Discrete Cosine Transform (DCT) is one of the most widely used techniques for image compression. Several algorithms are proposed to implement the DCT-2D. The scaled SDCT algorithm is an optimization of the DCT-1D, which consists in gathering all the multiplications at the end. In addition to the hardware implementation on an FPGA, an extended optimization has been performed by merging the multiplications in the quantization block without having an impact on the image quality.

A.K.T. Tan has researched in the improving mobile color 2D-barcode JPEG image readability using DCT coefficient distributions [12]. Two dimensional (2D) barcodes are becoming a pervasive interface for mobile devices, such as camera smart phones. Often, only monochrome 2D-barcodes are used due to their robustness in an uncontrolled operating environment of smart phones. Nonetheless, an emerging use of color 2D-barcodes for camera smart phones. Most smart phones capture and store such 2D-barcode images in the baseline JPEG format. As a lossy compression technique, JPEG does introduce a fair amount of error in the captured 2D-barcode images. The Discrete Cosine Transform (DCT) coefficient distributions of generalized 2D-barcodes using colored data cells, each comprising of 4, 8 and 10 colors have been analyzed in it. These DCT distributions improved the JPEG compression of such mobile barcode images.

V.K. Nath has illustrated on the comparison of generalized Gaussian and Cauchy distributions in modeling of dyadic rearranged 2D DCT coefficients [13]. The dyadic rearrangement of block two-dimensional Discrete Cosine Transform (2D DCT) coefficients when used with zero tree quantizers show comparable performance with that of discrete wavelet transform based methods for image compression applications. Recently, showed result of Generalized Gaussian distribution better models the statistics of subband rearranged 2D DCT coefficients compared to Gaussian, Laplacian and Gamma distributions. This has presented results of distribution tests that indicate that for most of the natural images Cauchy distribution models the subband coefficients more accurately than Generalized Gaussian distribution. The knowledge of the suitable distribution helps in design of optimal quantizers that may lead to minimum distortion and hence achieve optimal coding efficiency.

K.T. Tan has researched the JPEG compression of monochrome 2D-barcode images using DCT coefficient distributions [14]. Two dimensional (2D) barcodes are becoming a pervasive interface for mobile devices, such as camera phones. Often, only monochrome 2D-barcodes are used due to their robustness in an uncontrolled operating environment of camera phones. Most camera phones capture and store such 2D-barcode images in the baseline JPEG format. As a lossy compression technique, JPEG does introduce a fair amount of error in the decoding of captured 2D-barcode images. it introduced an improved JPEG compression scheme for such barcode images. By altering the JPEG compression parameters based on the DCT coefficient distribution of such barcode images, the improved compression scheme produces JPEG images with higher PSNR value as compared to the baseline implementation. We have also applied our improved scheme to a real 2D-barcode system - the QR Code and analyzed its performance against the baseline JPEG scheme.

E.D. Kusuma has studied in the FPGA implementation of pipelined 2D-DCT and quantization architecture for JPEG image compression [15]. Two dimensional DCT takes important role in JPEG image compression. Architecture and VHDL design of 2-D DCT, combined with quantization and zig-zag arrangement, has described. The architecture is used in JPEG image compression. DCT calculation used in this paper is made using scaled DCT. The output of DCT module needs to be multiplied with post-scaler value to get the real DCT coefficients. Post-scaling process is done together with quantization process. 2-D DCT is computed by combining two 1-D DCT that connected by a transpose buffer. This design aimed to be implemented in cheap Spartan-3E XC3S500 FPGA.

D. Jessintha has researched the energy efficient, architectural reconfiguring DCT implementation of JPEG images using vector scaling [16]. The DCT implementation of JPEG images using discrete cosine transform (DCT). The proposed method aims at reducing the power consumption which by application of vector scaling on DCT. This will be very useful for image compression and transmission applications. Using the character of energy distribution of DCT matrix after 2D-DCT operation, the best DCT basis functions are selected which is capable of achieving considerable power reduction with minimum image quality degradation. The proposed method can efficiently trade-off image quality and power consumption. An algorithm with vector scaled values for DCT coefficients is also proposed which reduces the computational energy based on the sensitivity differences of 64 DCT coefficients.

The 2D-DCT [16] can be computed by performing 1D-DCT for rows and columns separately as shown in the figure 2 below. The left most top corner value in the matrix of 8-by-8 is called as a "DC value" which is the average value of the block. All other values in the block are "AC values" which represents changes in a block across its height and width. The main idea behind doing the DCT is to separate out high and low frequency information in the image so that it becomes easy to eliminate the high frequency components without losing the low frequency components.

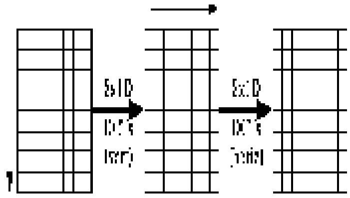

Fig. 1 Method for computing 2D-DCT using 1D-DCT

In the mathematical form, DCT for a given block of size N x N can be given by,

$$F_{uv} = \frac{1}{4} C_u C_v \sum_{y=0}^{N-1}\sum_{x=0}^{N-1} S_{yx} \cos\left(v\pi\frac{2y+1}{2N}\right)\cos\left(u\pi\frac{2x+1}{2N}\right)$$

$$C_u = \begin{cases} \frac{1}{\sqrt{2}} & \text{if } u = 0 \\ 1 & \text{else} \end{cases}$$

$$C_v = \begin{cases} \frac{1}{\sqrt{2}} & \text{if } v = 0 \\ 1 & \text{else} \end{cases}$$

1) *Discrete Cosine Transforms in Image Compression:* The discrete cosine transform (DCT) [13] – [16] is used to transform a signal from the spatial domain into the frequency domain. The reverse process, that of transforming a signal from the frequency domain into the spatial domain, is called the inverse discrete cosine transform (IDCT).

A signal in the frequency domain contains the same information as that in the spatial domain. The order of values obtained by applying the DCT is coincidentally from lowest to highest frequency.

This feature and the psychological observation [13] that the human eye and ear are less sensitive to recognizing the higher-order frequencies leads to the possibility of compressing a spatial signal by transforming it to the frequency domain and dropping high-order values and keeping low-order ones. When reconstructing the signal, and transforming it back to the spatial domain, the results are remarkably similar to the original signal.

This process, with a few extra bells and whistles and slightly modified versions of DCT, is the essence behind jpeg, mpeg, and mp3 compression.

Here, we look at a simplified case of compression using the DCT and IDCT [13] – [16] without bells and whistles. The process:

X = Apply DCT to a sequence of values.

X' = Drop a portion of high-order values from X.

X" = Apply IDCT to X'

Draw X" and observe the similarity to the original X.

III. CONCLUSION

After conducting the literature survey we have conclude that DCT based compression is much efficient than available techniques. By altering the JPEG compression parameters based on the DCT coefficient distribution of the images; one can improved compression scheme which may produces JPEG images with higher PSNR value as compared to the baseline implementation. In near future this work will be extend for selecting an important factor for DCT based technique and also at which level one reduce the size of given image.

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