A Review on Digital Image Compression Techniques

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Abstract: A large amount of digital data is needed to store an image . Due to the problem of limited bandwidth there is a need of image compression before it is transferred. For this several techniques have been developed in image processing. In this paper a detailed view of Lossy and Lossless image compression techniques covered. A comparisiobewn DWT and Neural Network techniques is done.

Keywords; *Lossy and Lossless Compression, Discrete Cosine Transform architecture (DCT), Discrete Wavelet Transforms (DWT), Neural Network.*

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1. Introduction

Image compression is the application of Data compression on digital images. The objective of image compression is to reduce redundancy of the image data in order to be able to store or transmit data in an efficient form. Compression is carried out for the following reasons as to reduce, the storage requirement, processing time and transmission duration. Image compression is minimizing the size in bytes of a graphics file without degrading the quality of image. Many applications need large number of images for solving problems. Digital images can be stored on disk, and storing space of image is important. Because less memory space means less time required for processing of image. Image compression can be lossy or lossless.[3] Lossless compression is sometimes preferred for artificial images such as technical drawings, icons or comics. This is because lossy compression methods, especially when used at low bit rates, introduce compression artifacts.[3] Lossless compression methods may also be preferred for high value content, such as medical imagery or image scans made for archival purposes. Lossy methods are especially suitable for natural images such as photos in applications where minor loss of fidelity is acceptable to achieve a substantial reduction in bit rate. The lossy compression that produces imperceptible differences can be called visually lossless.

A general compression model is shown in figure 1. It shows that encoder and decoder consist of two relatively independent functions or sub blocks . The encoder is made up of source encoder, which removes input redundancies, and a channel encoder, which increases the noise immunity of the source encoder's output. Similarly, the decoder includes a channel decoder followed by a source decoder. If the channel between the encoder and decoder is noise free, the channel encoder and decoder are omitted, and the general encoder and decoder is noise free, the channel encoder and decoder are omitted, and the general encoder and decoder become the source encoder and decoder, respectively[3].

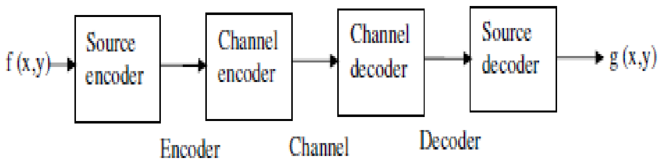

Figure 1: General Compression Model[3]

Compression Techniques

There are two types of compression algorithm: Lossless and Lossy. In the loss less compression the compressed image is totally replica of the original input image, there is not any amount of loss present in the image. While in Lossy compression the compressed image is not same as the input image, there is some amount of loss is present in the image.

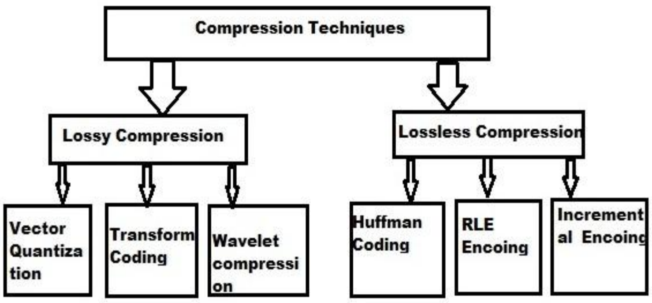

Figure 2 Compression techniques

A. Lossless compression Techniques

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In lossless compression scheme reconstructed image is same to the input image. Lossless image compression techniques first convert the images in to the image pixels. Then processing is done on each single pixel. The First step includes prediction of next image pixel value from the neighborhood pixels. In the second stage the difference between the predicted value and the actual intensity of the next pixel is coded using different encoding methods.

Different methods for Lossless compression are as follows:

Huffman Encoding

In this technique smaller bit code is given to the pixel values which occur frequently and the higher bit code for repeated pixel value. Huffman coding can reduce the file size by 10% to 50% by removing the irrelevant information[2]. In order to encode images the following steps are used:

1. First of all image is divided in to 8X8 blocks
2. Then each block is coded with particular symbols
3. Huffman code is applied to the each block
4. Encoding all the blocks

Run length encoding

The run length compression technique is useful in case of repetitive data. In this technique the sequence identical symbol or pixel is replace and it is known as run by shorter symbol[1]. The run length code gray scale image is represented by a sequence (Vi,Ri).where Vi is the intensity of pixel and Ri is the no of consecutive pixel with intensity as shown in figure

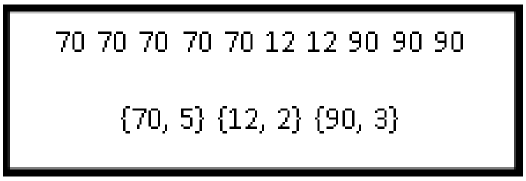

Figure 3 Run length encoding[1]

Incremental Encoding:

Incremental encoding is enhanced form of run length coding of lossless compression. This coding uses an array of sequence building up a two dimension object. The algorithms for this coding try to find rectangular region with the same characteristics and these regions are coding in a descriptive form as an element with two points and a certain structure. The problem with this coding is that, it cannot be implemented in hardware because of non-linear method[1].

B. Lossy Compression Technique

Lossy compression technique provides higher compression ratio compare to lossless compression. In this method, the compressed image is not same as the original image; there is some amount of information loss in the image.

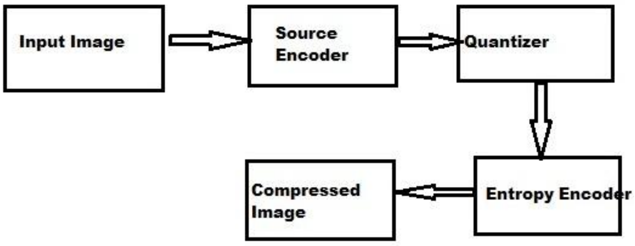

Figure 4 Lossy compression scheme[2]

Vector quantization

Vector quantization (VQ) technique develops a dictionary of fixed-size vectors which are called code vectors. A given image again partitioned into non-overlapping blocks called image vectors. Then for each image vector, the closest matching vector in the dictionary is determined and its index in the dictionary is used as the encoding of the original image vector . Because of its fast lookup capabilities at the decoder side, Vector Quantization-based coding schemes are normally used in multimedia applications.

Transformation coding:

In transformation coding less bandwidth is required. In this coding scheme transform such as DFT (discrete Fourier transform) and DCT (discrete coding transform) are used to change the pixel in the original image into frequency domain coefficients. These coefficients have several desirable properties; one is the energy compression property that results in most of the energy of the original data being concentrated in only a few of the significant transform coefficient. This is the basic of achieving the compression only few significant coefficients are selected and remaining are discarded. The selected coefficient are further quantization and entropy encoding. DCT coding has been the most common approach to transform coding .

Wavelet compression

Wavelet mean a “smallwave” the smallness implies to a window function of finite length. Wavelet are function that satisfy certain mathematically requirement and are used in representing data or other function. Wavelet compression involves a way of analyzing an uncompressed image in a recursive fashion, resulting in series of higher resolution images. The primary steps of wavelet compression are performing a Discrete Wavelet Transformation (DWT), quantization of the wavelet space image sub-band, and then encoding these sub-band that do the image compression. Image decompression, or reconstruction is achieved by carrying out the above steps in reverse and inverse order that is decode, dequantize and inverse Discrete Wavelet Transformation .

2 DWT AND NEURAL NETWORKS

In this section, neural network architecture for image compression is discussed. Feed forward neural network

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architecture and back propagation algorithm for training is presented. DWT based image transformation and compression is also presented in this section.

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 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. On the other hand, Neural networks are inherent adaptive systems they are suitable for handling non -stationeries in image data.

DWT architecture for image compression

The DWT represents the signal in dynamic sub-band Decomposition[4]. The Discrete Wavelet Transform (DWT), based on time-scale representation, provides multi-resolution sub-band decomposition of signals.

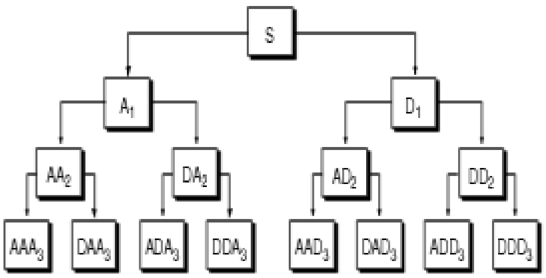

Figure 5 DWT decomposition[4]

In the above figure 5 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.

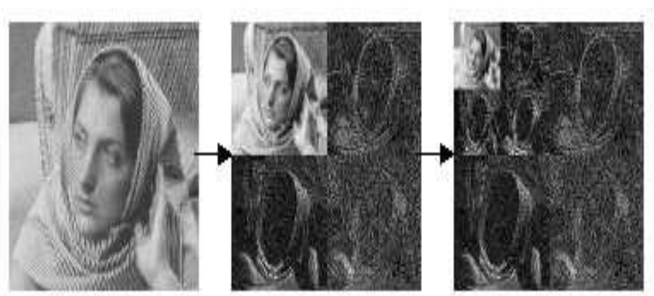

Figure 6 DWT decomposition of barbera image into hierarchical sub bands[4]

The barbera 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 in figure 6, 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.

Neural Network architecture for image compression

Neural Network are the simple clustering of the primitive artificial neurons. This clustering occurs by creating layers, which are then connected to one another. How these layers connect may also vary. Basically, all artificially neural networks have a similar structure of topology. Some of the neurons interface the real world to receive its inputs and other neurons provide the real world with the network's outputs. All the rest of the neurons are hidden form view. The input layer consists of neurons that receive input form the external environment. The output layer consists of neurons that communicate the output of the system to the user or external environment. There are usually a number of hidden layers between these two layers; the figure 7 below shows a simple structure with only one hidden layer.

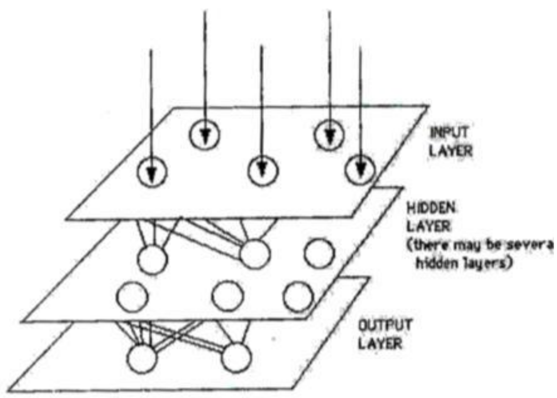

Figure 7 ***THREE layers for image compression***

The process continues until a certain condition is satisfied or until layer is invoked and fires their output to the external environment. To determine the number of hidden neurons the network should have to perform its best, one are often left out to the method trial and error. If the hidden number of neurons are increased too much an over fit occurs, that is the net will have problem to generalize. The training set of data will be memorized, making the network useless on new data sets.

3. Related work

S.M. Jayakar (2011) describes the performance of different wavelets using SPIHT[1] algorithm for compressing color image. In this R, G and B component of color image are converted to YCbCr before wavelet transform is applied. Y is luminance component; Cb and Cr are chrominance components of the image. Lena color image is taken for analysis purpose. Image is compressed for different bits per pixel by changing level of wavelet decomposition. Matlab software is used for simulation. Results are analyzed using PSNR and HVS property. Graphs are plotted to show the variation of PSNR for different bits per pixel and level of wavelet decomposition [12].

P.Tripathi (2012) defines the image compression is to reduce irrelevance image data in order to store the image in less memory space and to improve the transfer time of the image. Without compression, file size is significantly larger, usually several megabytes, but with compression it is possible to reduce file size to 10 percent from the original without noticeable loss in quality. There are so many compressions technique already presents a better technique which is faster and memory efficient. In this paper the Lossless method of Image Compression using Bipolar Coding Technique with LM algorithm in Artificial Neural Network is proposed by the author [1].

MV.Subbarao (2013) defines the Image compression is playing a key role in the development of various multimedia computer services and telecommunication applications. The ideal image compression system must yield good quality compressed images with good compression ratio, while maintaining minimal time cost. The goal of image compression techniques is to remove redundancy present in data in a way that enables image compression technique. There are numerous lossy and lossless image compression techniques. Wavelet-based image compression provides substantial improvements in picture quality at higher compression ratios. In this paper both of these methods for compression of images to obtain better quality [2].

G.kaur (2013) prescribes the Image compression is the application of Data compression on digital images. This paper entails the study of various image compression techniques and algorithms. Different techniques for digital image compression have been reviewed and presented that includes DFT, FFT, DCT and DWT. Wavelets , however has an advantage over older techniques that it doesn't have any blocking artifacts as in DCT. It is easy to implement and reduces the computation time and resources required. The discrete wavelet transform uses filter banks for the construction of the multi resolutional time-frequency plane. A new algorithm for image compression using Fast Wavelet Transform has been proposed as FWT reduces the problems of border distortions in Image Compression[4].

R.Vanaja and NL.Praba et.all (2013) presents a throughput efficient image compression using 'Set Partitioning in Hierarchical Trees' (SPIHT) algorithm for compression of images. The SPIHT use inherent redundancy among wavelet coefficients and suited for both gray and color image. The SPIHT algorithm uses dynamic data structures which hinders hardware realizations. In this FPGA implementation have modified basic SPIHT in two ways, one by using static mappings which represent significant information and the other by interchanging the sorting and refinement passes. Comparison of SPIHT in both the arithmetic coder and pipelined architecture was enumerated in this paper. [6].

F.Negahban (2013) describes a novel technique in image compression with different algorithms by using the transform of wavelet accompanied by neural network as a predictor. The details subbands in different low levels of image wavelet decomposition are used as training data for neural network. In addition, It predicts high level details subbands using low level details subbands. This Paper consists of four novel algorithms for image compression as well as comparing them with each other and well- known jpeg and jpeg2000 methods[7].

Comparison of DWT and Neural Network

Compression Method	DWT	NN
Compression ratio	Very good	Poor
Compression speed	Slow	Fast
Decompression speed	Slow	Fast
Memory space	Very low	Low
Compressed pattern matching	No	Yes
Permits Random access	No	Yes

Conclusion and future work:

This paper represent the concept of image compression and various technologies used in the image compression. A survey is performed on the most essential and advance compression methods, including coding techniques based on DCT, DWT, VQ, Fractal approach and other methods. In addition, this study reviewed about the efficient architecture for DWT for image compression applications and implementation of DWT architectures is discussed. In future work Neural network can be implemented using the LM algorithm.

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