Lossless Image Compression using Discrete Cosine Transform Algorithm

Miss Pooja Jain [1], Mr. Divyanshu Rao [2], Prof. Ravimohan [3]
Digital communication engineering [1,2,3]
Department of Electronics & Communication [1,2,3]
M.tech-IVth semester [1] , Professor[2,3]
Shri Ram Institute of Technology [1,2,3]
Rajeev Gandhi Technical University, Jabalpur, Madhya Pradesh, India [1,2,3]

Abstract- **Cameras are nowadays being provided with more and more megapixels to improve the quality of captured images. With improvement in image quality, size of the image file also increases. Due to speed limitation of the Internet, it takes more time to upload good-quality images that are of bigger sizes. A user needs to compress the image without degrading its quality. Mobile manufacturers need algorithms in their cameras that enable storing the images in reduced sizes without degrading their quality.**

Keywords – **Lossless compression, Image Compression, JPEG, Discrete Cosine Transform.**

I. INTRODUCTION

Lossless compression is a class of data compression algorithms that allows the original data to be perfectly reconstructed from the compressed data. By contrast, lossy compression permits reconstruction only of an approximation of the original data, though this usually improves compression rates (and therefore reduces file sizes).

Lossless data compression is used in many applications. For example, it is used in the ZIP file format and in the GNU tool gzip. It is also often used as a component within lossy data compression technologies (e.g. lossless mid/side joint stereo preprocessing by the LAME MP3 encoder and other lossy audio encoders).

Lossless compression is used in cases where it is important that the original and the decompressed data be identical, or where deviations from the original data could be deleterious. Typical examples are executable programs, text documents, and source code. Some image file formats, like PNG or GIF, use only lossless compression, while others like TIFF and MNG may use either lossless or lossy methods. Lossless audio formats are most often used for archiving or production purposes, while smaller lossy audio files are typically used on portable players and in other cases where storage space is limited or exact replication of the audio is unnecessary.

Most lossless compression programs do two things in sequence: the first step generates a statistical model for the input data, and the second step uses this model to map input data to bit sequences in such a way that "probable" (e.g. frequently encountered) data will produce shorter output than "improbable" data.

The primary encoding algorithms used to produce bit sequences are Huffman coding (also used by DEFLATE) and arithmetic coding. Arithmetic coding achieves compression rates close to the best possible for a particular statistical model, which is given by the information entropy, whereas Huffman compression is simpler and faster but produces poor results for models that deal with symbol probabilities close to 1.

There are two primary ways of constructing statistical models: in a static model, the data is analyzed and a model is constructed, then this model is stored with the compressed data. This approach is simple and modular, but has the disadvantage that the model itself can be expensive to store, and also that it forces using a single model for all data being compressed, and so performs poorly on files that contain heterogeneous data. Adaptive models dynamically update the model as the data is compressed. Both the encoder and decoder begin with a trivial model, yielding poor compression of initial data, but as they learn more about the data, performance improves. Most popular types of compression used in practice now use adaptive coders.

Lossless compression methods may be categorized according to the type of data they are designed to compress. While, in principle, any general-purpose lossless compression algorithm (general-purpose meaning that they can accept any bit string) can be used on any type of data, many are unable to achieve significant compression on data that are not of the form for which they were designed to compress. Many of the lossless compression techniques used for text also work reasonably well for indexed images.

II. LOSSLESS MODE OF OPERATION

Lossless JPEG is actually a mode of operation of JPEG. This mode exists because the discrete cosine transform (DCT) based form cannot guarantee that encoder input would exactly match decoder output. Unlike the lossy mode which is based on the DCT, the lossless coding process employs a simple predictive coding model called differential pulse code modulation (DPCM). This is a model in which predictions of the sample values are estimated from the neighboring samples that are already coded in the image. Most predictors take the average of the samples immediately above and to the left of the target sample. DPCM encodes the differences between the predicted samples instead of encoding each sample independently. The differences from one sample to the next are usually close to zero. A typical DPCM encoder is displayed in Fig.1. The block in the figure acts as a storage of the current sample which will later be a previous sample.

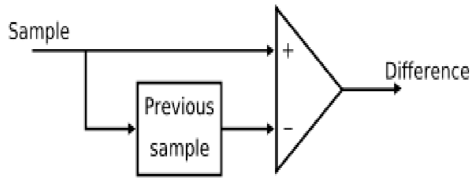


Fig 1: DPCM encoder model

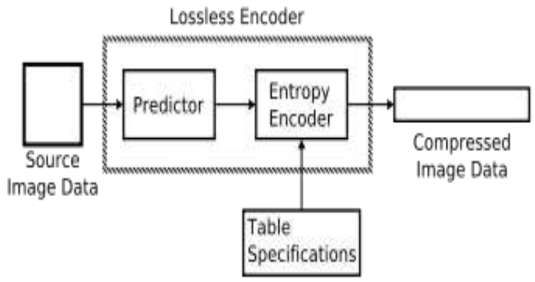


Fig2: Simplified Block Diagram for Lossless Mode

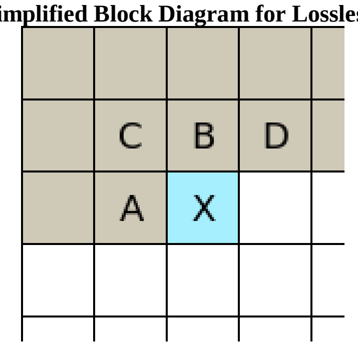


Fig 3: 3 Neighboring samples around the samples to be predicted

The main steps of lossless operation mode are depicted in Fig.2. In the process, the predictor combines up to three neighboring samples at A, B, and C shown in Fig.3 in order to produce a prediction of the sample value at the position labeled by X. The three neighboring samples must be already encoded samples. Any one of the predictors shown in the table below can be used to estimate the sample located at X.[2] Any one of the eight predictors listed in the table can be used. Note that selections 1, 2, and 3 are one-dimensional predictors and selections 4, 5, 6, and 7 are two-dimensional predictors. The first selection value in the table, zero, is only used for differential coding in the hierarchical mode of operation. Once all the samples are predicted, the differences between the samples can be obtained and entropy-coded in a lossless fashion using Huffman coding or arithmetic coding.

Selection-value	**Prediction**
0	No prediction
1	A
2	B
3	C
4	A + B – C
5	A + (B – C)/2
6	B + (A – C)/2
7	(A + B)/2

Typically, compressions using lossless operation mode can achieve around 2:1 compression ratio for color images.[3] This mode is quite popular in the medical imaging field, and defined as an option in DNG standard, but otherwise it is not very widely used because of complexity of doing arithmetic's on 10, 12 or 14bpp values on typical embedded 32bit processor and a little resulting gain in space.

III. LITERATURE REVIEW

In Many of these methods are implemented in open-source and proprietary tools, particularly LZW and its variants. Some algorithms are patented in the United States and other countries and their legal usage requires licensing by the patent holder. Because of patents on certain kinds of LZW compression, and in particular licensing practices by patent holder Unisys that many developers considered abusive, some open source proponents encouraged people to avoid using the Graphics Interchange Format (GIF) for compressing still image files in favor of Portable Network Graphics (PNG), which combines the LZ77-based deflate algorithm with a selection of domain-specific prediction filters. However, the patents on LZW expired on June 20, 2003.

According *to A.M.Raid, W.M.Khedr, M. A. El-dosuky and Wesam Ahmed* in paper "Jpeg Image Compression Using Discrete CosineTransform'- A Survey Due to the increasing requirements for transmission of images in computer, mobile environments, the research in the field of image compression has increased significantly. Image compression plays a crucial role in digital image processing, it is also very important for efficient transmission and storage of images.When we compute the number of bits per image resulting from typical sampling rates and quantization methods, we find that Image compression is needed. Therefore development of efficient techniques for image compression has become necessary .This paper is a survey for lossy image compression using Discrete Cosine Transform, it covers JPEG compression algorithm which is used for full-colour still imageapplications and describes all the components of it

In *Image Compression Using Wavelet Methods* by Yasir S. AL - MOUSAWY, Safaa S. MAHDI the aims to study and compare the compression efficiencies of wavelet-bitmap and wavelet-Huffman. Both methods use wavelet to deduct a portion of the information in the image that can endure losing it without a significant disturbance in the image itself. Both methods deal with thresholding of wavelet coefficients to produce as much as possible zero coefficients for the purpose of higher compression, then encode the non zero coefficients by using Huffman encoding and bitmap drawing of the coefficients distribution resulted from thresholding inside the analyzed image. The processing time is calculated using MATLAB. Results were taken to compare the efficiencies of the compression between the two methods. In this work we present a method based on wavelet transforms using Huffman encoding and bitmap encoding. Different combinations of parameters and transforms have been compared. The result shows that the time of compression in wavelet-bitmap method is less than the time of compression which is taken by wavelet-Huffman method. Also the compression ratio in the wavelet-Huffman is greater than the other method. The quality in both methods is relatively equal.

IV. PROPOSED METHOD

Loss Less Compression Methods

By operation of the pigeonhole principle, no lossless compression algorithm can efficiently compress all possible data. For this reason, many different algorithms exist that are designed either with a specific type of input data in mind or with specific assumptions about what kinds of redundancy the uncompressed data are likely to contain. Some of the most common lossless compression algorithms are listed below.

General purpose

- Run-length encoding (RLE) – a simple scheme that provides good compression of data containing lots of runs of the same value.
- Lempel-Ziv 1978 (LZ78), Lempel-Ziv-Welch (LZW) – used by GIF images and compress among many other applications
- LZF - Basic LZ-compression ("deflate"), optimized for fast compression ("Lempel-Ziv Fast")
- DEFLATE – used by gzip, ZIP (since version 2.0), and as part of the compression process of Portable Network Graphics (PNG), Point-to-Point Protocol (PPP), HTTP, SSH
- bzip2 – using the Burrows–Wheeler transform, this provides slower but higher compression than DEFLATE
- Lempel–Ziv–Markov chain algorithm (LZMA) – used by 7zip, xz, and other programs; higher compression than bzip2 as well as much faster decompression.
- Lempel–Ziv–Oberhumer (LZO) – designed for compression/decompression speed at the expense of compression ratios
- Statistical Lempel Ziv – a combination of statistical method and dictionary-based method; better compression ratio than using single method.
- Brotli – a modern LZ-based compression method that is roughly as fast as DEFLATE, but gives a compression ratio similar to LZMA

Audio

- Apple Lossless (ALAC - Apple Lossless Audio Codec)
- Adaptive Transform Acoustic Coding (ATRAC)
- apt-X Lossless
- Audio Lossless Coding (also known as MPEG-4 ALS)
- Direct Stream Transfer (DST)
- Dolby TrueHD
- DTS-HD Master Audio
- Free Lossless Audio Codec (FLAC)
- Meridian Lossless Packing (MLP)
- Monkey's Audio (Monkey's Audio APE)
- MPEG-4 SLS (also known as HD-AAC)
- OptimFROG
- Original Sound Quality (OSQ)
- RealPlayer (RealAudio Lossless)
- Shorten (SHN)
- TTA (True Audio Lossless)
- WavPack (WavPack lossless)
- WMA Lossless (Windows Media Lossless)

Graphics

- PNG – Portable Network Graphics
- TIFF – Tagged Image File Format
- WebP – (high-density lossless or lossy compression of RGB and RGBA images)
- BPG – Better Portable Graphics (lossless/lossy compression based on HEVC)
- FLIF – Free Lossless Image Format
- JPEG-LS – (lossless/near-lossless compression standard)
- TGA - Truevision TGA
- PCX - PiCture eXchange
- JPEG 2000 – (includes lossless compression method, as proven by Sunil Kumar, Prof San Diego State University)
- JPEG XR – formerly WMPhoto and HD Photo, includes a lossless compression method
- ILBM – (lossless RLE compression of Amiga IFF images)
- JBIG2 – (lossless or lossy compression of B&W images)

PGF – Progressive Graphics File (lossless or lossy compression

3D Graphics

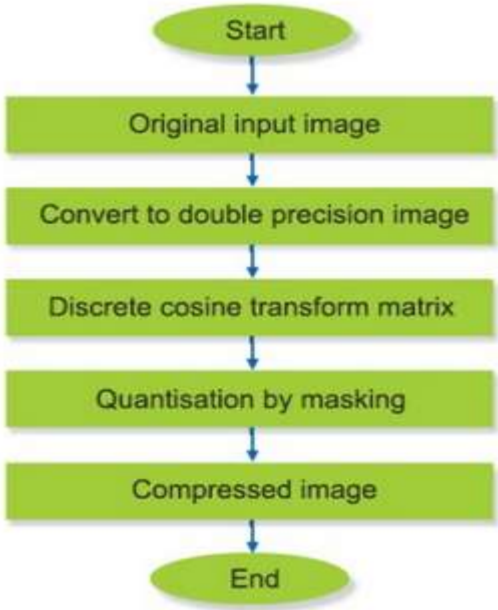
- OpenCTM – Lossless compression of 3D triangle meshes

V. RESULT AND CONCLUSION

There are two types of compression algorithms, namely, loss-less and lossy-image compression. This article proposes a technique to compress the captured image to reduce its size while maintaining its quality. A number of images were considered to check the veracity of the proposed algorithm.

Original image sample 1

In this project, discrete cosine transform algorithm is used, which compresses the image with a good compression ratio.



The flowchart of the process is shown in Fig. 1.

The image is read through MATLAB to capture its pixels. After obtaining the compressed image, peak-signal-noise ratio (PSNR) and mean-square error (MSE) are calculated using the following relationships:

$$MSE = \frac{\sum_{M,N}(\text{Image1}(m,n) - \text{Image2}(m,n))^2}{m \times n}$$

where m and n are the number of rows and columns. Image1 and Image2 are the original and compressed images, respectively.

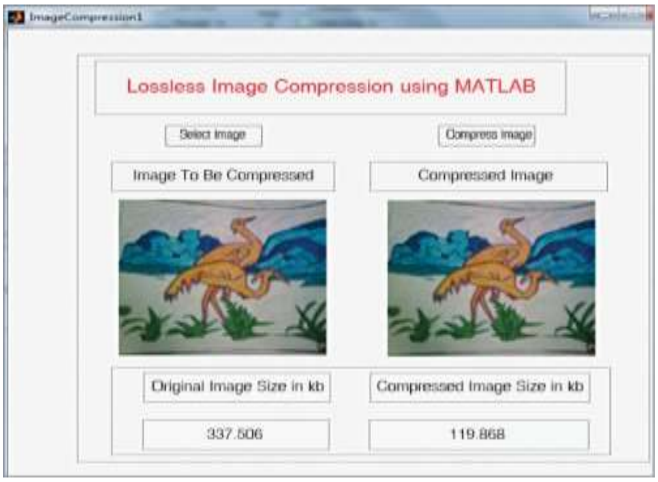


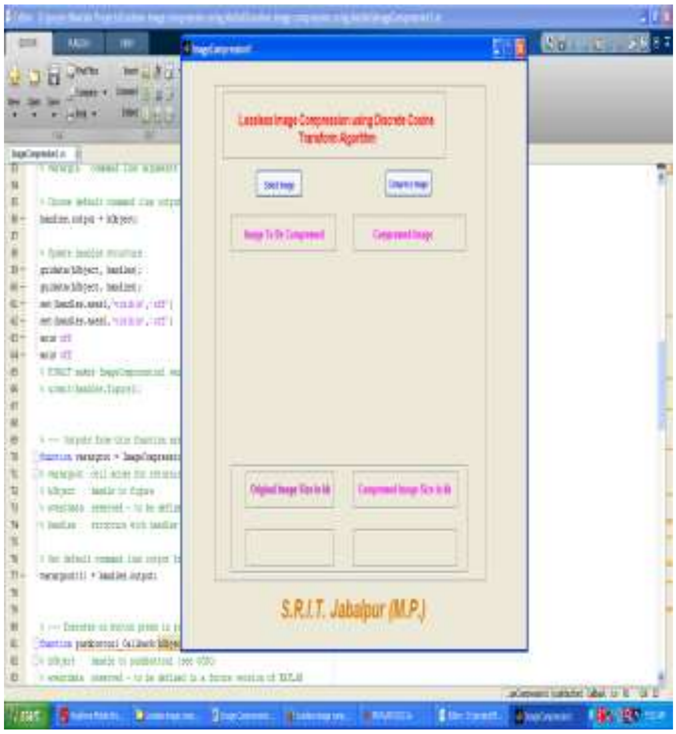
Fig. 3: MATLAB implementation of image sample1

After compression, there should not be much change in the quality of the image. MSE indicates an error between the original image and compressed image. It should be as small as possible.

where R is the maximum fluctuation in the input image data type (maximum possible pixel value of image). PSNR is related to MSE and it gives the amount of noise in a compressed image. PSNR should be as high as possible.

$$PSNR = 10 \log_{10} \left(\frac{R^2}{MSE} \right)$$

equations are implemented in MATLAB in the form of functions.



VI. REFERENCES

[1] S. V. Viraktamath" Performance Analysis of JPEG Algorithm" 978-1-61284-653-8/11/$26.00 ©2011 IEEE1

[2] Wei Zheng," Research in a Fast DCT Algorithm Based on JPEG" 978-1-61284-459-6/11/$26.00 ©2011 IEEE

[3] Jingpeng LU "Survey on the Technology of Image Processing Based on DCT Compressed Domain" 978-1-61284-774-0/11/$26.00 ©2011 IEEE

[4] XiHong ZHOU" Research on DCT -based Image Compression Quality" 978-1-4244-9793-5/11/$26.00 ©2011 IEEE

[5] Zheng Wei" Analysis of JPEG Encoder for Image Compression" 978-1-61284-774-0/11/$26.00 ©2011 IEEE

[6] Ken and cabeen"Image compression and DCT Cosine Transformation" Math 45, College of the Redwood.

[7] G. Valenzise, M. Tagliasacchi, S. Tubaro "The cost of JPEG compression anti-forrensics" 978-1-4577-0539-7/11/$26.00 ©2011 IEEE

[8] Tiziano Bianchi, Alessandro Piva," Detection of nonaligned double jpeg compression with estimation of primary compression parameters"18th IEEE International Conference on Image Processing, 978-1-4577-1303-3/11/2011.

[9] Lin Ma, Student Member, Songnan Li, Student, Fan Zhang, and King Ngi Ngan,'' Reduced-Reference Image Quality Assessment Using Re organized DCT-Based Image Representation'' IEEE, VOL. 13, NO. 4, AUGUST 2011.

[10] Nabila Brahimi, Saad Bouguezel, "An Efficient Fast Integer DCT Transform for Images Compression with 16 Additions Only" 7th International Workshop on Systems, Signal Processing and their Applications (WOSSPA) -2011.

[11] Aree Ali Mohammed, Jamal Ali Hussein, "Hybrid Transform Coding Scheme for Medical Image Application" 978-1-4244-9991-5/11/2011.

[12] N. Memon and K. Sayood. Lossless image compression: A comparative study. Proc.SPIE Still-Image Compression, 2418:8–20, March 1995.

[13] N. Memon and K. Sayood. Lossless compression of rgb color images. Optical Engineering, 34(6):1711–1717, June 1995.
[14] S. Assche, W. Philips, and I. Lemahieu. Lossless compression of pre-press images using a novel color decorrelation technique. Proc. SPIE Very High Resolution and Quality Imaging III, 3308:85–92, January 1998.
[15] N. Memon, X. Wu, V. Sippy, and G. Miller. An interband coding extension of the new lossless jpeg standard. Proc. SPIE Visual Communications and Image Processing, 3024:47–58, January 1997.
[16] N. Memon and K. Sayood. Lossless compression of video sequences. IEEE Trans. On Communications, 44(10):1340–1345, October 1996.
[17] S. Martucci. Reversible compression of hdtv images using median adaptive prediction and arithmetic coding. Proc. IEEE International Symposium on Circuits and Systems, pages 1310–1313, 1990.

