

Study, Analysis, Implementation and Comparison between JPEG and JPEG2000

Thazin Aungsoe (13504163)

Department of Informatics Engineering, Institute of Technology Bandung

E-mail : if14163@students.if.itb.ac.id

Abstract - Because of the excess use of images in various areas and fields, compression algorithm for image became popular and necessary to reduce the size of the image whenever needed. Different kinds of compression algorithms are developed and used for different purposes and most of them are already standardized by several international organizations. Each algorithm has its own advantages and disadvantages.

In this final year project, analysis towards JPEG and JPEG2000 image compression algorithms will be done and then these two algorithms will be implemented into application. Firstly, theories of JPEG and JPEG2000 will be studied in detail. After that, analysis will be processed towards these two compression algorithms. The result of analysis will be implemented into application called **CompareJJ2k**. The application CompareJJ2k is developed using visual C++ programming language with Microsoft .NET framework. Open source library of JPEG and JPEG2000 will be used in implementation. After application is implemented, testing will be done to see whether CompareJJ2k application met the functional requirements defined in analysis stage. Testing will be done with the provided image which includes grey scale and color image with different size. The results will be compared in five different parameters such as file size, time to compress image, compression ratio, PSNR and MSE to see why JPEG is more popular than JPEG2000.

Key words: JPEG, JPEG2000, Image compression, compression, DCT, DWT, PSNR, MSE

1. Introduction

Over the past few years, the amount of data in various uses became large. Every minute, data are increasing because data are being used widely in all kinds of industry nowadays. Data are used not only for computer industries, but also for business, medicine, government and social. These data include text, image, video and audio.

Among them, the amount of digital images we use every day is increasing continuously, these images are also becoming larger and larger and the need of storage also increases. To achieve the required resolution, size for multimedia applications or to handle large image databases using the current computers, compression techniques are needed. Image compression is the technique to

compress the image to the minimum size or available size of our like so that we can store more images in our limited space and also the use of our resources can be decreased.

JPEG is the first international image compression standard for continuous tone still images-both grayscale and color images. To overcome the inefficiencies in the JPEG standard and serve emerging applications areas in this age of mobile and Internet communications, the new JPEG2000 standard has been developed based on the principles of DWT and currently more developments in this standard are still in progress in the ISO/IEC standard committee.

JPEG2000 is developed as a better version of JPEG yet we still use JPEG

more widely than JPEG2000. In this final year project, JPEG and JPEG2000 will be compared from various points of views to see why JPEG is more popular than JPEG2000.

2. Literature Study

2.1 Digital Image

A digital image is a rectangular array of dots, or picture elements, arranged in m rows and n columns. The expression $m \times n$ is called the resolution of the image, and the dots are called *pixels*. The term “resolution” is sometimes also used to indicate the number of pixels per unit length of the image.

2.2 Compression

Compression is the technique to reduce the redundancies in data representation in order to decrease data storage requirements and hence communication costs. Reducing the storage requirement is equivalent to increasing the capacity of the storage medium and hence communication bandwidth. Compression is performed by a program that uses a formula or algorithm to determine how to compress or decompress data. In other words, Data compression is the process of converting an input data stream into another data stream that has a smaller size.

2.3 JPEG

In the baseline mode, the image is divided in 8×8 blocks and each of these is transformed with the DCT. The transformed blocks are quantized with a uniform scalar quantizer, zig zag scanned and entropy coded with Huffman coding. The quantization step size for each of the 64 DCT coefficients is specified in a quantization table, which remains the same for all blocks.

The DC coefficients of all blocks are coded separately, using a predictive scheme.

Compression technique in JPEG is a symmetric compression technique which means compression process and decompression process in JPEG use the same basis algorithm but with different direction. For general, symmetric compression of JPEG compression and decompression is described in Figure 1 and Figure 2. Because of the symmetric process, the exploration will be mainly focus on the compression process of JPEG.

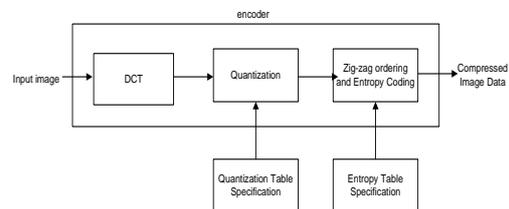


Figure-1 JPEG Lossy Compression

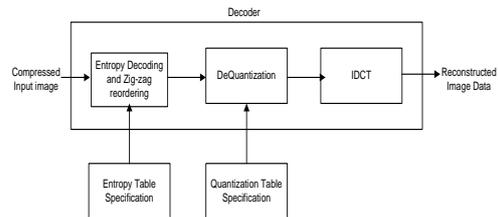


Figure - 2 JPEG Lossy Decompression

2.4 JPEG2000

JPEG2000 is one of the standard and newest in making compression for digital images which is resulted from ISO with ITU (International Telecommunication union). JPEG2000 is included in symmetric compression method where compression and decompression based on the same algorithm but different directions. General picture of JPEG2000 process can be seen in Figure 3. The source image Data will be firstly pre procession and then transform with DWT. Then the result will be quantized and entropy coding. At last the

compressed image data is produced. Because of compression method as in JPEG, the exploration of JPEG2000 will be focus on the compression process of JPEG2000.

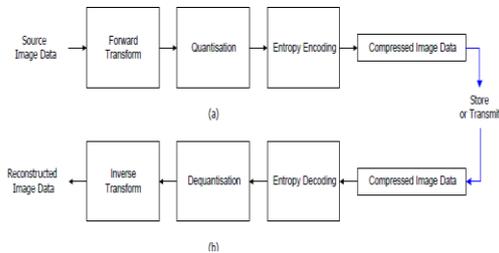


Figure -3 Block diagrams of the JPEG2000 (a) encoder and (b) decoder [CHR00]

2.5 Quality of compression result in visual

Firstly, Measuring the quality of compression result towards the original image will be done by calculating MSE value (Mean Square Error) and also PSNR value (Peak Signal-to-noise ratio). MSE value from digital image with the size of $N \times M$ will be calculated by the following formula:

$$MSE = \frac{1}{M \cdot N} \sum_{m=0}^{M-1} \sum_{n=0}^{N-1} |f(m, n) - \hat{f}(m, n)|^2$$

$F(m, n)$ is the original digital image before compression, while $\hat{f}(m, n)$ is the compressed digital image. The big MSE value describes that the differences between original image and compressed image is quite big.

PSNR can be calculated by using the following formula:

$$PSNR = 20 \log_{10} \left[\frac{MAX}{\sqrt{MSE}} \right]$$

MAX is the maximum possible intensity value in the image. For example for eight bits depth images $MAX = 2^8 - 1 = 255$. If PSNR is bigger, then quality of the compressed digital image is better because there is not

much change of data from original image.

2.6 Degree of compression

The compression ratio gives the ratio between the original and compressed file sizes. It is a dimensionless quantity and is often stated as:

$$compression\ ratio = \frac{original\ file\ size}{compressed\ file\ size}$$

The disadvantage of this metric is that it can be changed just by padding the original representation of the data to more bits.

3. Analysis and Design

3.1 General Description of system

Application to be developed, as have already explained in previous chapter – study literature, is the application to compress digital image of the certain format which is the input from the user and will produce the compressed digital image in JPEG and JPEG2000 format. This application is named as CompareJJ2k. Application CompareJJ2k have a special feature, which compare the result of JPEG and JPEG2000 image in some aspects and will give result to the user.

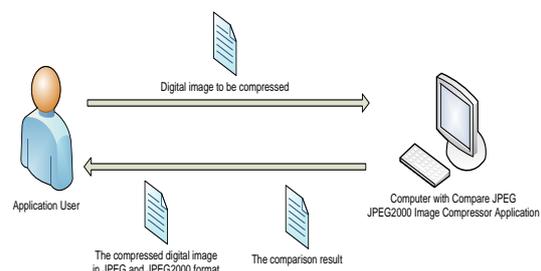


Figure -4 Software Architecture

3.2 Product function

Some of the main functions from CompareJJ2k application are as follows:

1. Can display digital image with certain format, i.e., 24bpp bitmap.
2. Can compress the input digital image and produce the compressed digital image with format JPEG and JPEG2000 (*.jpg, *.j2k).
3. User can do the decompression process to the digital image with JPEG and JPEG2000 format and can display the result on the application layer.
4. Can save the result compression and decompression image into file.
5. Can calculate PSNR form the result digital image.
6. Can calculate degree of compression.
7. Can display the result of the comparison between JPEG and JPEG2000. The result includes information about file size, time of compression, MSE, PSNR and degree of compression.
8. Can display the decompression file size and time to decompress the image.
9. Can display 'help' and 'about' for the application.

3.3 Functional requirement analysis

Functional requirements and description of software will be described in Use Case Diagram as in figure 5.

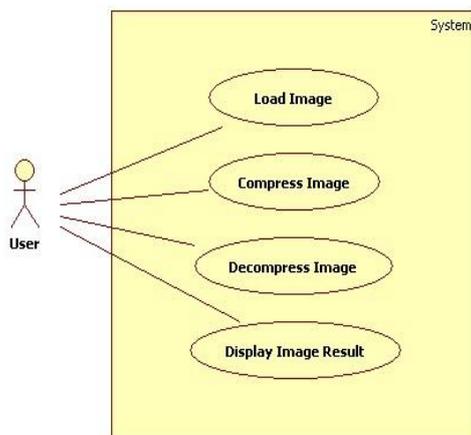


Figure-5 UseCase Diagram

4. Implementation and Testing

4.1 Implementation

CompareJJ2k is implemented by using programming language C and C++ with Microsoft visual studio .NET IDE software. CompareJJ2k uses some predefined function of JPEG and JPEG2000 library from open source which is already implemented in C language.

Moreover, the other software which is useful in doing this final year project is:

1. Microsoft Office Word 2007 for writing the document.
2. Microsoft Office Visio 2003 for figure and interface design.
3. StarUML for making *use case and class diagram*.

The hardware environment are

- | | | |
|---|--------------|------------------------------|
| 1 | Monitor | : 14'' |
| 2 | CPU | : AMD Turion
64x2 1.9 GHz |
| 3 | Harddisk | : 80GB |
| 4 | Graphic Card | : GeForce 7000M
128 MB |
| 5 | Memory | : 1536 MB DDR
SDRAM |
| 6 | Input device | : Keybord device,
mouse |

4.2 Testing

The purposes of testing towards the CompareJJ2k application are:

1. To know the correctness of the compress image and decompressed. Testing will be done to see whether the JPEG and JPEG2000 image will be produce after the process compressing and to see the BMP image will be output after the decompressing process.
2. To know the performance from the JPEG and JPEG2000 image by

comparing the result from JPEG and JPEG2000.

- To calculate the PSNR and MSE value and compression ratio from original image and compression image.

4.2.1 Testing result of compression image

Table -1result of compression image

No.	Process	Result
1.	The result of JPEG and JPEG2000 image file	Success
2.	Displaying of JPEG image	Success
3.	Displaying of JPEG2000 image	Success

4.2.2 Testing result of decompression image

Table-2result of decompression image

No.	Process	Result
1.	The result file of BMP image from JPEG	Success
2.	The result file of BMP image from JPEG2000	Success
3.	Displaying the output image	success

4.2.3 Testing result of comparison parameters

Table-3result of comparison parameters

Original File Name	Parameters	JPEG	JPEG2000
GREY_LENA512.bmp	File size (B)	33951	141354
	Compression Ratio	7.753	1.86215
	Time(s)	0.102601	0.711753
	MSE	16958.6	13326.7
	PSNR	53.9677	55.0144
SMALL_Fruits.bmp	File Size	33755	16185
	Compression Ratio	9.01146	1.85268
	Time	0.0826364	0.804752
	MSE	20707	12322
	PSNR	53.1003	55.3547
LENA_ME	File size	37788	445142

DIUM.bmp	Compression Ratio	20.8131	1.76682
	Time	0.189255	2.08449
	MSE	17103.1	9043.77
	PSNR	53.9309	56.6981
BIG_MAN.bmp	File size	82261	536440
	Compression Ratio	15.2468	2.33803
	Time	0.338909	3.02764
	MSE	7113.87	13174.4
	PSNR	57.7406	55.0643
VBig_chev.bmp	File size	696430	2250939
	Compression ratio	21.7058	6.71569
	Time	3.92052	21.8117
	MSE	5943.7	9092.11
	PSNR	58.521	56.675

4.2.4 Testing result of comparing result from ACDSee

Table -4result of comparing result from ACDSee

Original Name and Image size	CompareJJ2k		ACDSee 9 Photo Manager	
	JPEG	JPEG2000	JPEG	JPEG2000
Grey_small_lena256.bmp (66KB)	11KB	36KB	18KB	7KB
Grey_lena512.bmp(258KB)	34KB	139KB	63KB	26KB
Medium_lena.bmp(769KB)	37KB	161KB	77KB	77KB
Small_fruits.bmp(298KB)	33KB	435KB	47KB	30KB
Big_man.bmp (1.25MB)	81KB	524KB	157KB	123KB
Vbig_chev.bmp(14.76MB)	681KB	2.199MB	1.354MB	1.47MB

5. Closing

5.1 Conclusion

The conclusions that can be taken from the implementation of this final year project are as follows:

- JPEG image compression algorithm produce the smaller file size image than the JPEG2000 compression

- algorithms and the time to compress JPEG image is also very small.
2. JPEG2000 compression and decompression algorithms are very complicated and need many calculations of difficult mathematical equation.
 3. Both JPEG and JPEG2000 can compress and decompress Grey scale image as well as colour image.
 4. The quality of JPEG2000 compression result is usually better because JPEG2000 has bigger PSNR value. But if the input image file is bigger than 1MB, then PSNR for JPEG became bigger than JPEG2000.
 5. Finally, JPEG compression algorithm is more popular than JPEG2000 algorithm because JPEG is more efficient for many purposes which probably doesn't need the quality of the image and only focus on compression time, smaller file size and bigger compression ratio.
 6. The use of JPEG and JPEG2000 library from open JPEG and independent JPEG group is very useful only with a small bug.

5.2 Suggestion

The followings are some suggestion to make more improvement or perfection of the idea related to this final year project topic are:

1. Can do more exploration towards JPEG2000 compression method because there are still many features which don't cover in this project such as:
 - a. Exploration of Region of Interest (ROI) of JPEG2000.
 - b. Exploration of lossy technique because this project only develop lossless technique for JPEG2000.
 - c. Can be developed application which use other formats other BMP and J2k.

d. Exploration of JPWL (Wireless JPEG2000)

2. Should also explore about other JPEG method like progressive or hierarchy method.

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