

Comparison of different image compression formats

ECE 533 Project Report
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Introduction:

Images are very important documents nowadays; to work with them in some applications they need to be compressed, more or less depending on the purpose of the application. There are some algorithms that perform this compression in different ways; some are lossless and keep the same information as the original image, some others loss information when compressing the image. Some of these compression methods are designed for specific kinds of images, so they will not be so good for other kinds of images. Some algorithms even let you change parameters they use to adjust the compression better to the image.

My aim with this project was to make a comparison of some of the most used image representation formats on a set of images. I have been working with very different types of images: true color, greyscale, scanned documents and high resolution photographs.

I have seen how well the different formats work for each of the images. There are some formats that match some images better than others depending in what you are looking for to obtain, and the type of image you are working with.

Lossless image representation formats:

BMP (bitmap) is a bitmapped graphics format used internally by the Microsoft Windows graphics subsystem (GDI), and used commonly as a simple graphics file format on that platform. It is an uncompressed format.

PNG (Portable Network Graphics) (1996) is a bitmap image format that employs lossless data compression. PNG was created to both improve upon and replace the GIF format with an image file format that does not require a patent license to use. It uses the DEFLATE compression algorithm, that uses a combination of the LZ77 algorithm and Huffman coding.

PNG supports palette based (with a palette defined in terms of the 24 bit RGB colors), greyscale and RGB images. PNG was designed for distribution of images on the internet not for professional graphics and as such other color spaces

Comparison with JPEG:

- JPEG has a big compressing ration, reducing the quality of the image, it is ideal for big images and photographs.
- PNG is a lossless compression algorithm, very good for images with big areas of one unique color, or with small variations of color.
- PNG is a better choice than JPEG for storing images that contain text, line art, or other images with sharp transitions that do not transform well into the frequency domain.

Comparison with TIFF:

- TIFF is a complicated format that incorporates an extremely wide range of options. While this makes it useful as a generic format for interchange between professional image editing applications, it makes supporting it in more general applications such as Web browsers difficult.
- The most common general-purpose lossless compression algorithm used with TIFF is LZW, which is inferior to PNG and until expiration in 2003 suffered from the same patent issues that GIF did.

TIFF (Tagged Image File Format) (last review 1992) is a file format for mainly storing images, including photographs and line art. It is one of the most popular and flexible of the current public domain raster file formats. Originally created by the company Aldus, jointly with Microsoft, for use with PostScript printing, TIFF is a popular format for high color depth images, along with JPEG and PNG. TIFF format is widely supported by image-manipulation applications, and by scanning, faxing, word processing, optical character recognition, and other applications.

Compression types include

- uncompressed
- PackBits - is a fast, simple compression scheme for run-length encoding.
- Lempel-Ziv-Welch (LZW)
- CCITT Fax 3 & 4 – protocol for sending fax documents across telephone lines
- JPEG (see below)

Until recently the use of this LZW was limited because this technique was the subject of several patents in various jurisdictions.

Sometimes CCITT encoding is referred to, not entirely accurately, as Huffman encoding. CCITT 1-dimensional encoding is a specific type of Huffman encoding. The other types of CCITT encodings are not, however, implementations of the Huffman scheme.

Lossy image compression formats:

JPEG (Joint Photographic Experts Group) (1992) is an algorithm designed to compress images with 24 bits depth or greyscale images. It is a lossy compression algorithm. One of the characteristics that make the algorithm very flexible is that the compression rate can be adjusted. If we compress a lot, more information will be lost, but the result image size will be smaller. With a smaller compression rate we obtain a better quality, but the size of the resulting image will be bigger. This compression consists in making the coefficients in the quantization matrix bigger when we want more compression, and smaller when we want less compression.

The algorithm is based in two visual effects of the human visual system. First, humans are more sensitive to the luminance than to the chrominance. Second, humans are more sensitive to changes in homogeneous areas, than in areas where there is more

variation (higher frequencies). JPEG is the most used format for storing and transmitting images in Internet.

JPEG 2000 (Joint Photographic Experts Group 2000) is a wavelet-based image compression standard. It was created by the Joint Photographic Experts Group committee with the intention of superseding their original discrete cosine transform-based JPEG standard.

JPEG 2000 has higher compression ratios than JPEG. It does not suffer from the uniform blocks, so characteristics of JPEG images with very high compression rates. But it usually makes the image more blurred than JPEG.

Summary of the formats:

FORMAT	NAME	CHARACTERISTICS
BMP	Windows bitmap	Uncompressed format
TIFF	Tagged Image File Format	Lossless: Document scanning and imaging format. Flexible: LZW, CCITT, RLE,
PNG	Portable Network Graphics	Lossless: improve and replace GIF. Based on the DEFLATE algorithm.
JPEG	Joint Photographic Experts Group	Lossy: big compression ratio, good for photographic images
JPEG 2000	Joint Photographic Experts Group 2000	Lossy: eventual replacement for JPEG

EXPERIMENTS:

Lossless image representation formats. True color image:

This image is a 24 bit depth image. I compressed it with TIFF and PNG. The uncompressed image is in BMP and has a size of 696KB. This image is a very good image to compress with lossless algorithms, because it has lots of areas of homogeneous colors, so we can see that both TIFF and PNG perform very well. PNG is more powerful than TIFF. I have also compress it with JPEG to see what would be the size of it compressed with a lossy algorithm.

The ratio of compression for TIFF is around 2:1, for PNG is around 2,7:1 and for JPEG we obtained a compression ratio of 16:1.



BMP 696 KB



TIFF-LZW 378KB



PNG 258KB



JPEG 43,3KB

Lossless image representation formats. Greyscale image:

This image is a greyscale image, each pixel is 8 bits. I compressed it with TIFF and PNG. The uncompressed image is in BMP and has a size of 257KB. The size is smaller than the previous one because it is greyscale, but we will see that because it has much more detail than the previous images, the result of compression with lossless algorithms is not very good. I have also compressed it with JPEG to see what would be the size of it compressed with a lossy algorithm, we see that the compression ratio for this format is also much smaller in this picture than in the previous one.

The ratio of compression for TIFF is around 1:1, for PNG is around 1.5:1 and for JPEG we obtained a compression ratio of 3.2:1.



BMP 257 KB



TIFF LWZ 251KB



PNG 173 KB



JPEG 79 KB

Lossless image representation formats. Scanned document:

This is a binary image, 1 bit depth. The image is a scanned document with a very high resolution. The uncompressed image is in BMP and has a size of 1.1MB. I will see the performance of the TIFF algorithm CCITT4, a standard designed for text documents in fax machines. I will compare the result with PNG and also JPEG. We can see that any of those algorithms perform better than TIFF. JPEG does not even compress the image because it does not perform very well for diagrams with lines and text.

The ratio of compression for TIFF is around 21.5:1, for PNG is around 11.2:1 and for JPEG we obtained no compression.



BMP 1,07MB



TIFF CCITT4 50,9KB



PNG 97,1KB



JPEG 1M

Lossy image representation format: JPEG. True color image:

The original image here is a true color image (24 bits per pixel). The size of the original image in BMP is: 768KB. It is a proper image to compress with JPEG, and not with lossless compression algorithms, PNG and TIFF achieve no compression at all for this image. This is because it is an image with lots of very bright colors and textures.

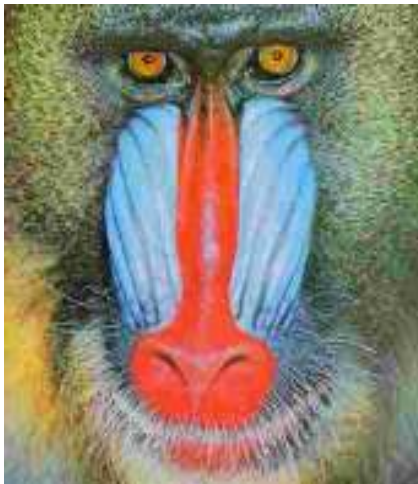
JPEG allows the user to choose a number between 100 and 1 to adjust the compression that we want to obtain. The higher the number, the less compression we will obtain, and the better quality the image will have. For this experiment I show the result for a compression quality of: 100, 50, 10 and 1.



Quality 100 334KB



Quality 50 49,5KB



Quality 10 16,3KB



Quality 1 6,3KB

You can see how the image losses its bright colors and becomes more blurred. With quality 1, the characteristics squares appear in the image. When the quality parameter that we choose is smaller than 50, we can see how the image losses quality rapidly and the error from the original image gets much more important.

Here is the error that we obtain for the previous compressed images when they are decompressed and compared to the original BMP image. We see how the error is gets more important as the chosen number for the quality decreases. In the error computed with the image compressed with quality 1, you can clearly distinguish the image.



Quality 100



Quality 50



Quality 10



Quality 1

Lossy image representation format: JPEG 2000. True color image:

Here I proved that the compression format JPEG 2000 is much more powerful than JPEG. For the same size images in JPEG and JPEG 2000 we can see how much better JPEG 2000 performs. Although JPEG 2000 is not very extended yet, it will be a powerful replacement for JPEG.

The first image is the baboon image; we can see that the image in JPEG has the characteristics rectangular regions due to the low quality JPEG compression. JPEG 2000 blurs slightly the image when compressing with very low quality.



JPEG 6,3KB



JPEG 2000 6,3KB

Here we have the result of the compression for a high quality photographic image. We can see how the colors are very poor and wash out for the JPEG image, but not for the JPEG 2000. JPEG 2000 preserves all the major details of the original picture.



JPEG 148KB



JPEG 2000 148KB

References:

- The JPEG web page: <http://www.jpeg.org/>
- Wikipedia: <http://es.wikipedia.org>
- Digital Image Processing, 2nd edition, by Gonzalez & Woods

Programs used:

- MATLAB
- ACDSee 9 Photo Manager