Comparison and Application Possibilities of JPEG and Fractal-based Image Compressing Methods in the Development of Multimedia Based Material

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Extended Abstract

1. Introduction

Digitised visual information plays a great role in most multimedia based material. Even CD-ROMs are being outgrown by higher-level applications. Although a new technology (DVD) was introduced last year, the data structure optimised for this is likely to condense visual information in a losing way. There are several good methods based on adaptive DCT. A less well-known but extremely effective one is the fractal compression method based on the identification of the inner structure of images.

To take the end users' point of view into consideration we carried out psychovisual contrastive analysis between two losing condensing methods (JPEG, FIF) and between these methods and decompressed images. The research was carried out under laboratory circumstances and was based on Internet questionnaires.

2. The JPEG Standard [5, 10, 11]

The JPEG (Joint Photographic Experts Group) standard is an adaptive discrete cosines transformation (DCT) based image condensing method developed by a workgroup formed by experts from ISO (International Standards Organisation) and CITT (Consultation Committee on International Telephone and Telegraph) in 1986.

After a slight deterioration of the view an approximately 1/30 compression can be achieved. The rate of compression and the extent of occasional deterioration can be regulated by user parameters. The developers of JPEG standard payed special attention to the effective use of this method both in hardware and software.

The method handles each RGB (colour scheme) separately so that if compressing was not a losing one the colour-system in which the pixels were described would not matter. However, since JPEG allows losing it is better to choose the description which is the least sensible to mistakes and which makes the greatest condensing rate possible.

This way JPEG uses the YUV colour system instead of RGB and the data of colour constituents are divided into more and less important ones. Human sight is much less sensitive to so called crominance constituents than to luminance ones. Therefore the colour picture is worth for transforming into this colour system before condensing.

We are not intending to deal with detailed description of this condensing method because of the wide range of background literature, we would only like to briefly sum up its main features.

The strip of the image describing the particular colour constituent can be divided into separate sections of 8*8 pixels. Transformation will result in 8*8 = 64 co-efficient belonging to two-dimensional discrete base-functions. This process can be expressed like this:

(1)

$$DCT(k_1,k_2)=\sum_{n_1=0}^{N-1}\sum_{n_2=0}^{N-1}x(n_1,n_2)*\cos(2p(2n_1+1)k_1*(4N)^{-1})*$$
$$\cos(2p(2n_2+1)k_2*(4N)^{-1}).$$

where : N is the size of a section (in JPEG: 8)

$x(n_1,n_2)$ is the value of pixel

n_1,n_2,k_1,k_2 section-relative positions

This formula is not suitable for direct calculation because it needs a large number of operations to be carried on based on real values. Transformation can very effectively be calculated by the RVFFT (Real Valued Fast Fourier Transform) method for example.
Although there is strong correlation among the 64 pixels of the section , the 64 co-efficient after the transformation do not show any inherence.
Psychovisual studies verified that the 64 co-efficient are not equally important in creating a picture nearly as good as the original image (the base functions representing a higher-frequency image content do not play much role in creating the view). This way when doing quantilization the co-efficient it is taken into consideration that the co-efficient belonging to the higher-frequency constituents can be less accurately coded than the ones belonging to lower-frequency.
The standard is widely spread (WWW, Multimedia, DVD etc.), widely known and can easily be adapted to several applications.

3. Fractal-based compressing

Michael Barnsley's compressing method based on fractal transformation is entirely different from and more efficient than the ones based on DCT transformation.
The main point in the fractal-based compression of toned or coloured images is that most natural images contain sharp edges, continuous transitions and frequently occurring patterns.
The compressing program first divides the hole image into small sections, then finds the most similar image (range) which is different from the domain in size and location. When storing only the colour of the domain and the data about the transformation should be saved.
The mathematical transformational methods necessary to the transformation are well-known.
The objects in digital images about the real world can be shrivelled into an optional size [3], [6], [7], [8].
The mathematical transformational methods behind are well-known [1], [2], [9]. The task is to recognise and identify the objects in the picture with the help of fractals. Apart from the introduction of the detailed mathematical method [2] we can state that there is an efficient implementation of the transformation. Although the calculating needs of the method is in the case of a 800x600x24 pixelxpixelxbit image, with a Pentium 100 processor takes about 1-2 minutes; with a Pentium 200MMX processor about 1/2 minute, the calculation needs of present popular processors is already suitable for the task. Since decompressing can be done more rapidly / in the case of an 800x600x24 pixelxpixelxbit image, with a Pentium 100 processor still only 1-2 seconds / than compressing, users sometimes do not realise it in the case of images in multimedia applications. After decompression the image can be magnified and this way seemingly new details appear by the local repetition of global patterns.

4. Material /images, compressing programs/

Measurements were made based on two questionnaires:

- Laboratory conditions / same background light, monitors of the same quality of 17" and equal eye-monitor distance/.

- A test sheet available on the Internet with recommendations helping evaluations.

Each of the original pictures was made in Kodak colour slide and then transfer onto PhotoCD through digitalisation made by a Kodak RFS 2035 scanner.

The JPEG images were prepared with the help of PhotoShop 3.0 and 4.0 , and they were compressed based on 24-bit uncompressed TIFF images. Fractal-based compressions were made with the help of a freely downloadable program /Fractal Imager 1.1/ from the server of Iterated Systems Incorporation / http://www.iterated.com /. The size of each image was 640 x 480 x 24 (pixel x pixel x bit).
During the comparisons with the original images the quantitative factors of the two methods were chosen so that the size of the gained files would be roughly similar. Still, the size of JPEG images was nearly twice as big as that of the FIF images. Although during the comparison with each other the maximal quantitative factor was set in both cases of compression, the size of JPEG images was twice as big as the FIF images.

5. Test items

The following points were taken into consideration when selecting the test questions:

- questions could also be answered by people with minimum professional knowledge
- questions should be easily adaptable for WWW
- answers should be given providing similar circumstances
- questions should be short and easily understandable
- the way of answering the questions should be easy (tick the answer)
- a questionnaire should include a maximum of ten question items

The following table shows the comparison of elements important from the point of view of evaluation:

Essential point of views of questions (i)	Number of relating questions	Comparison
Extent of details original + magnified	2+2	Decompressed - JPEG
Shades	2	Decompressed - JPEG
Saturation of colours	2	Decompressed - JPEG
Extent of details original + magnified	2+2	Decompressed - FIF
Shades	2	Decompressed- FIF
Saturation of colours	2	Decompressed - FIF
Shades	1	FIF-JPEG
Recognizability	1	FIF-JPEG

Table 1.
The comparison of elements important from the point of view of evaluation

Each person filled in two questionnaires, during laboratory measurement. One questionnaire compared the uncompressed images with JPEG images; the other compared fractal-compressed images with uncompressed ones.

We asked two questions between both questionnaires, comparing JPEG and fractal-based methods. The questions referring to the comparison of uncompressed and compressed /JPEG or fractal-based/ images were the following:

1. To what extent do the two images differ in terms of visibility?
2. To what extent do the two images differ in terms of distortion of geometric figures?
3. To what extent do the two images differ in terms of shade?
4. To what extent do the two images differ in terms of saturation?
5. To what extent did the visibility of small parts of the image change after an enlargement of 2 times?
6. To what extent did the visibility of small parts of the image change after an enlargement of 4 times?
7. To what extent did the shade of small parts of the image change after an enlargement of 2 times?
8. To what extent did the saturation of the image change after an enlargement of 4 times?

The questions referring to the comparison of JPEG and FIF images were the following:

9. Is there any difference between the recognizablity of figures of the two images?
10. Is there any difference between the separation of shades of the two images?

The questions of the Internet questionnaire [12]:

1. To what extent do the two images /JPEG and FIF/ differ in terms of visibility of small parts?
2. To what extent do the two images /JPEG and FIF/ differ in terms of distortion of geometric figures?
3. To what extent did the visibility of the small parts of the images /JPEG and FIF/ change?
4. To what extent do the two images /JPEG and FIF/ differ in terms of changes in saturation ?
5. To what extent did the shade of the image /FIF/ change after an enlargement of 2 times / in case of a detailed image/?
6. To what extent did the saturation of the image /FIF/ change after an enlargement of 4 times /in case of a detailed image/?
7. To what extent did the shade of the image /FIF/ change after an enlargement of 2 times /in case of an image full of shades/?
8. To what extent did the saturation of the image /FIF/ change after an enlargement of 4 times /in case of an image full of shades/?
9. In your subjective opinion to what extent do the two images /JPEG and FIF/ differ in terms of the recognizability of figures (to what extent are the edges sharp)?
10. In your subjective opinion to what extent do the two images /JPEG and FIF/ differ in terms of separation of shades?

6. Results

6.1. Results of laboratory examination [4]

Laboratory examinations so far were done with the help of more than 100 people, Internet examinations were done based on the results of more than 200 people. In case of laboratory examination 80 per cent of the participants studied advanced informatics. 40 per cent of the total number studied multimedia based subjects / multimedia devices, multimedia software, computer aided graphics/. 10 per cent studied digital image processing at a theoretical and practical level.
Figure 1. shows the results of comparison of uncompressed and JPEG-compressed images under laboratory circumstances.
We can state that in case of nearly all the questions /the first 8/ users found the difference between the JPEG images 1/30 compressed images and uncompressed images disturbing.
What nearly everybody found extremely disturbing was the 'digital' effect when enlarging the images.
In the case of answers given for the same questions referring to fractal-compressed and uncompressed images some user found the difference disturbing /Figure 2/. The 'digital' effect that is so disturbing for human brain did not occur. When comparing the two methods of compression there was significant difference to the advantage of fractal-compressed images /Figure 3/. This could mainly be realised in the shades.

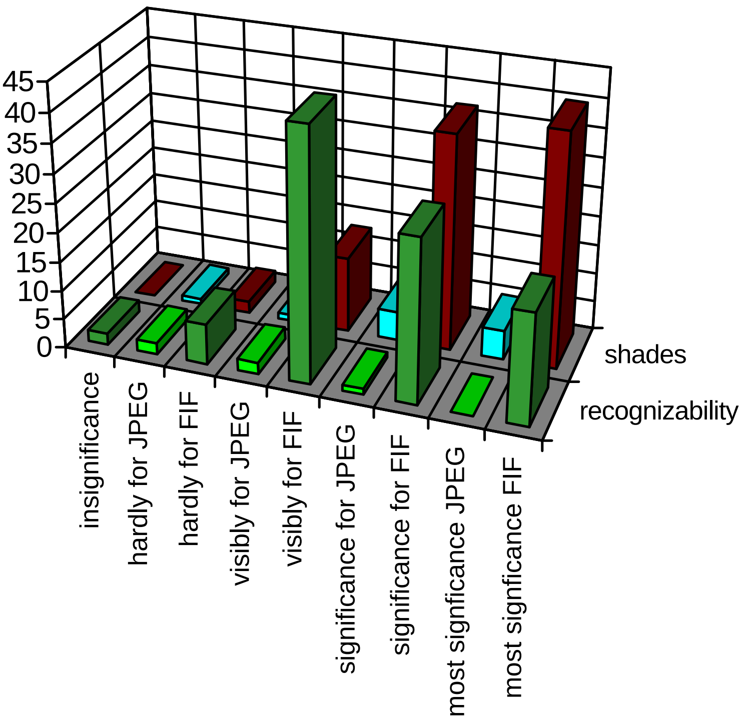

Figure 1.
Results of the comparison of uncompressed and JPEG compressed images under laboratory circumstances

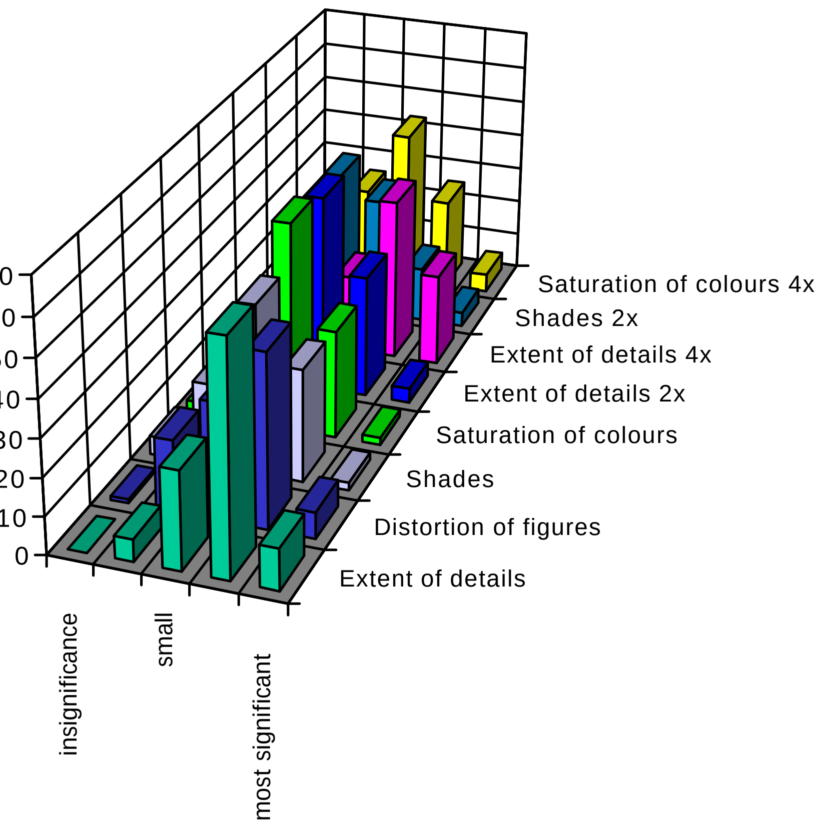

Figure 2.
Results of comparison of uncompressed and FIF images under laboratory circumstances

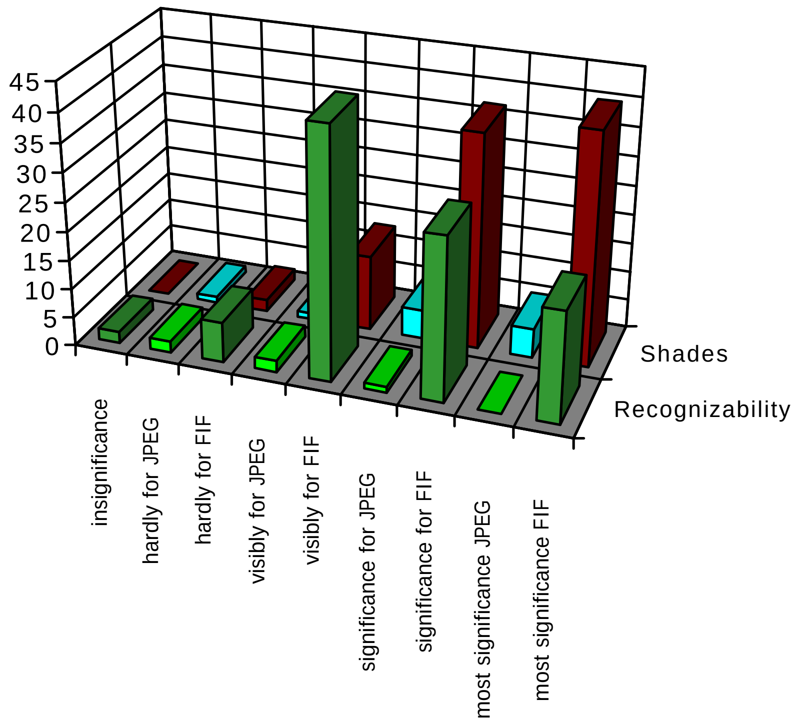

Figure 3.
Results of comparison of JPEG and fractal compressed images under laboratory circumstances

6.2. Results of Internet questionnaire

People answering:

• Rate of Females / Males	≈ 1 : 5
• Age of the youngest person	10 years
• Age of the oldest person	51 years
• Average age	≈ 27 years

The WWW version of the test is available at the following address [12]: http://www.georgikon.pate.hu/visual.htm.
Six questions among the ten (first 4 and last 2) refer to the comparison of JPEG and fractal-compressed images, while the others refer to fractal-compressed images full of shade and detail.
When evaluating the results of the Internet-test we could state that there is a significant quantitative difference to the fractal-compressed images between JPEG images of the original size and FIF images. /see Table 2. and Figure 4./.
There was a great qualitative difference to the advantage of FIF pictures in the magnified (2 times) part of the original JPEG and fractal image both in shades and details (Picture 9 - 4.18, Picture 10 - 3,87). Using the magnification of the compressing method we examined what the opinion of the individual users' is in terms of the deterioration due to magnification in the case of an image rich in shades (questions 7-8) and an image rich in geometric details (questions 5-6).
Although there is a significant and sometimes disturbing difference in case of a four-time magnification of FIF images (in case of JPEG images the four-time magnification is very disturbing), in case of images rich in shades the effect of two-time magnification is very small (2,16 ± 1,12). We were surprised to see that in case of images rich in shades even the effect of four-time magnification is nearly unrecognisable. (2,67 ± 1,17).
This verifies the fact that the fractal-based compression of images rich in shades is really good, the deterioration as an effect of magnification is very small - hardly recognisable (much better than in case of JPEG images).

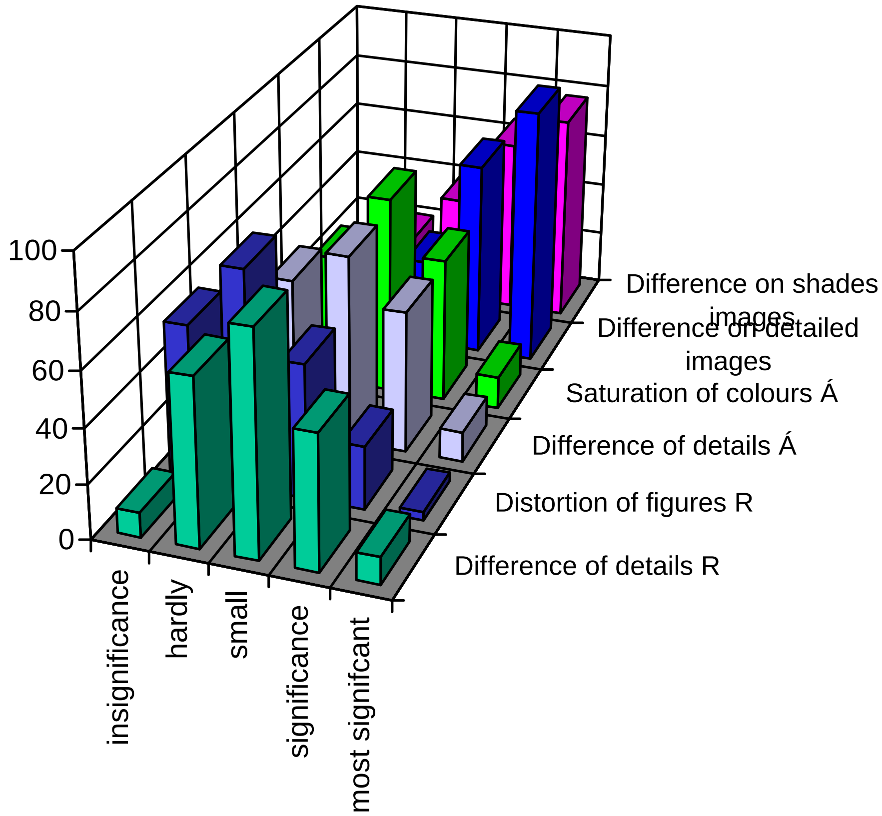

Figure 4.
Results of comparison of JPEG - fractal compressed images based on Internet

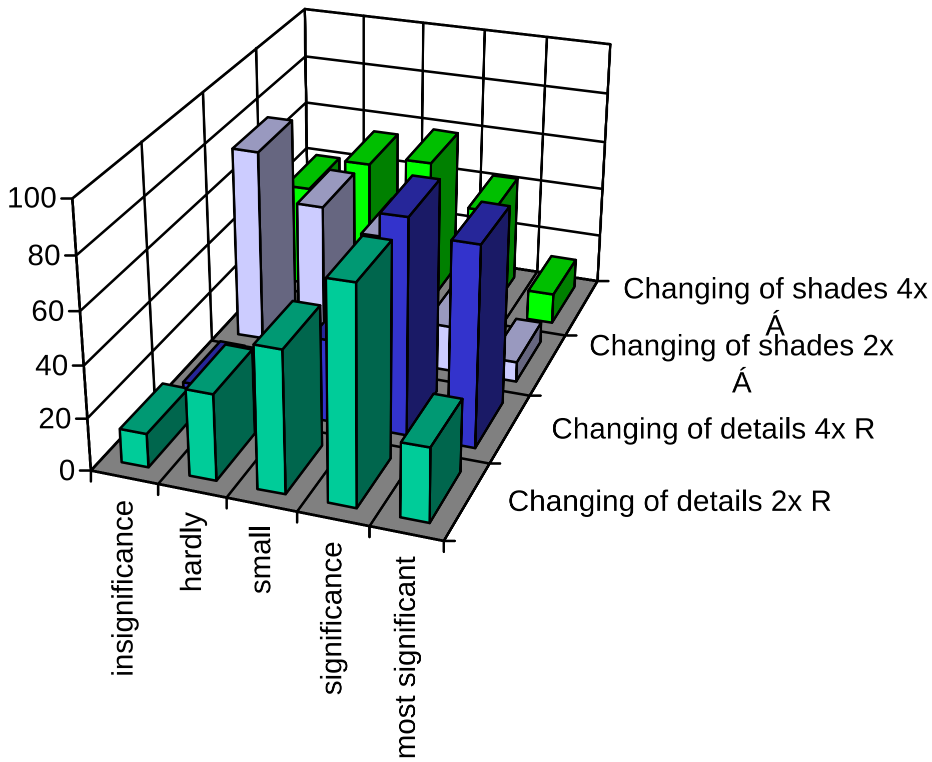

Figure 5.
Results of magnification in case of fractal compressed images based on Internet questionnaires / "R" denotes the image rich in details, "Á" denotes images rich in shades. /

Question	Average	Standard deviation
1.	**2,95**	***0,94***
2.	**2,23**	***1,01***
3.	**2,88**	***1,06***
4.	**2,91**	***1,08***
5.	**3,38**	***1,09***
6.	**4,02**	***0,99***
7.	**2,16**	***1,12***
8.	**2,67**	***1,17***
9.	**4,18**	***0,93***
10.	**3,87**	***1,13***

Table 2.
Summary of answers to the Internet questions

7. Possible Applications in case of Multimedia-based developments

When developing multimedia-based material the format in which we want to enclose our images is an important question. It is a more crucial question if we want our material to appear in commerce because the cost of developing CDs (master copy and copies) is changing according to the amount of data on the disk. In the case of fractal-based compression we can save space and money. Our studies verified that this compression method also results in an improvement in quality in the case of raster image size (640x480, 800x600, 1024x768). This is extremely true in the case of images full of shades, and in the case of the enlargement of parts.

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