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THE HALF-BYTE DESCRIPTOR FOR IMAGE DATA UNITS

The paper presents proposal for image data unit description using a half-byte format. It was implemented for medical images description. The introduced definitions express pixel values using differences between pixels and the introduced base value. This way the image recorded at half-byte format can be simply compressed by an appropriate compression, methods more effectively. The half-byte format is suitable for so called "natural" images with textures that are usually compressed with not satisfying results. For the given method illustration some example results were introduced.

1. INTRODUCTION

Contemporary medical systems utilise lossless image compression. The data files, containing images, are remarkable large. For the file size reduction different compression methods are applied. Effectiveness of compression is described by the compression factor that presents the ratio of the image file size before compression and after this operation.

Many methods of compression were already elaborated, both lossless and lossy [2], [3], [4]. The methods are differing from their complexity and effectiveness. The lossless compression algorithms create an image representation, which allows as full reconstruction of the image. Applying the lossy compression a part of image information is rejected leading to remarkable reduction of the image representation.

The compression factors obtained as a result of lossy compression are bigger than in lossless compression methods. However lossy compression destroys significantly the image quality in reconstructed data file. It means that the lossy compression method can not be recommended for many areas, as for majority branches of medicine. The image compression can incorporate preliminary format for the data streamlining algorithms [1], [5].

Discussed in the paper the half-byte compression data format is in fact not the compression technique. The data conversion algorithm produces a new image, where pixels are described by differences between pixel values and the base values. The pixel differences can be coded by 4 bits then pairs of these codes are put into one byte.

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2. THE METHOD PRINCIPLES

Digital image is analysed as two-dimensional object interpreted as a table of values describing pixel shade levels. In the method greyscale images, with 8 bits per pixel (8 bpp), are examined. The 8 bpp greyscale image can be interpreted as an image at one byte format. The 8 bpp resolution is sufficient for the majority of technical applications (with resolutions of 256 x 256).

Many of image classes distinguish images with regions of pixels, of similar value. These image regions can be described by sequences, consisting of a base pixel value and a set of difference values between a current and base pixel values.

It is assumed that the difference between the base and individual pixel values does not exceed 15. This permits as 4 bit coding implementation. This way a one byte base pixel value is divided into two half byte units. The sequence of the half byte pixel values determines the whole image region. Linking the all individual regions (the half byte sequences) into one sequence gives the half byte sequence of the entire image.

The sequence of the half byte values is converted into sequence of bytes by assembling neighbouring half bytes into one byte. This is carrying out, both for base half bytes and difference half bytes. The discussed conversion produces the half-byte image representation. The half-byte format allows us reducing the size of image files.

Images recorded in the half-byte format may be further compressed using any well known compression method. However for obtaining relatively high compression-factor, the method should be correlated to the half byte processing algorithm. The introduced half-byte format is found as a suitable assignment for so called “nature” images description.

2.1. ENCODING

The examined image with the resolution of 256 x 256 pixels is described by the image matrix denoted ***X*** with elements $x_{m,n}$. The conversion vectors were denoted appropriately ***Y*** and ***Z***, half-byte vector as ***H***. They are created in order to carry out the processing method. The image was divided into separated square units with resolution of *RB* x *RB* pixels. Each unit is assigned with its coordinates *j* (rows), *k* (columns) and ordinal block number - *NB* assigned as:

$$NB = \frac{256}{RB}\left(j-1\right)+k, \qquad j = 0, 1, \ldots \frac{256}{RB}, \qquad k = 0, 1, \ldots \frac{256}{RB}. \tag{1}$$

The image matrixes ***X*** are transformed into conversion vector ***Y***. The transformation of a single block, with block coordinates *j, k* and pixel coordinates *m*, *n* inside the data unit, to appropriate elements of vector ***Y*** describes equation

$$y^{(j,k)}_{i+(NB\cdot RB\cdot RB)} = x_{m+(j\cdot RB),\ n+(k\cdot RB)} \tag{2}$$

where:

$i = 0, 1, \cdots, RB^2,$
$n = 0, 1, \cdots, RB,$
$m = 0, 1, \cdots, RB,$ for even n,
$m = RB, RB-1, \cdots, 0,$ for odd n.

All units of the matrix ***X*** are transformed into conversion vector ***Y***. Next step concerns calculations of the conversion vector ***Z***, by the arithmetic operators div (integer division) and mod (remainder), by expressions

$$\begin{aligned} z_{2i} &= y_i \operatorname{div} 16, \\ z_{2i+1} &= y_i \operatorname{mod} 16. \end{aligned} \tag{3}$$

The half-byte vector ***H*** is established on the base of conversion vector ***Z*** values. At the beginning the base value is set

$$\begin{aligned} h_0 &= z_0 , \\ h_1 &= z_1 . \end{aligned} \tag{4}$$

Then, an individual half byte values are written into vector ***H***. There are two cases: half byte marker c or half byte pixel value z_j (indexes of the vectors appropriately indicate current writing position)

$$h_i = \begin{cases} c, & \text{half byte marker} \\ z_j, & \text{half byte pixel value}. \end{cases} \tag{5}$$

For the half byte marker the new base value has to be written

$$\begin{aligned} h_{i+1} &= z_j , \\ h_{i+2} &= z_{j+1} \end{aligned} \tag{6}$$

where the new base for half byte value b is equal to

$$b = z_j \cdot 16 + z_{j+1} . \tag{7}$$

The output stream ***S*** was created by assembling the half bytes into the half-byte vector ***H***

$$s_i = h_{2i} \cdot 16 + h_{2i+1} . \tag{8}$$

Both types of the half bytes may be assembled together. The obtained output stream of the bytes (the assembled half bytes) is carried into the image output file.

2.2. DECODING

Decoding of the image at half-byte format is simple procedure and it is performed in reverse order to encoding.

The algorithm steps follow as:

- the input stream is split into half bytes and the half-byte vector ***H*** is appropriately defined,
- the conversion vector ***Z*** is filled up with its half byte values reconstructed on the base of the half-byte vector ***H***,
- the conversion vector ***Y*** is filled up with pixel values reconstructed on the base of values of conversion vector ***Z***,
- the image matrix ***X*** is filled up with pixel's values reconstructed on the base of conversion vector ***Y*** values.

The image that is obtained as a result of decoding of the half byte sequence and the source image are noticed the same. For some classes of images the conversion to the half-byte format gives a smaller representation than the original image.

The discussed half-byte format is recognised, in the discussed above cases, as the form of lossless compression method.

3. SOME EVALUATION RESULTS

The half-byte format conversion was applied to four test images: Image 1, Image 2, Image 3 and Image 4. The algorithm evaluation images were extracted from magnetic resonance data records [6]. The all test images are recorded in greyscale, with 8 bits per pixel (8 bpp) and with the resolution of 256 x 256 pixels. The evaluation images are shown in Fig. l to Fig. 4, at the left side of the figures. The four test images were converted into the half-byte formats. The images at the half-byte format were presented at the right side of each figure.

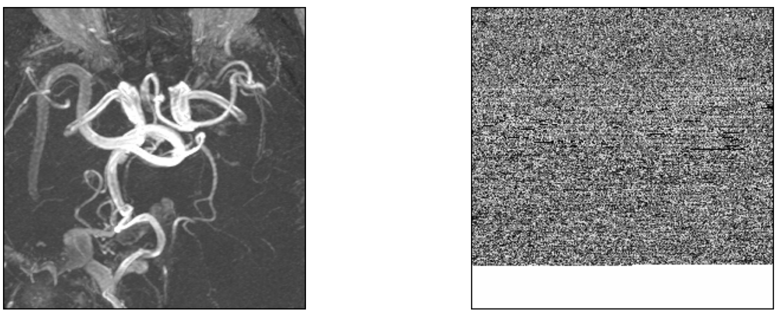

Fig.1. Image 1 and its half-byte format

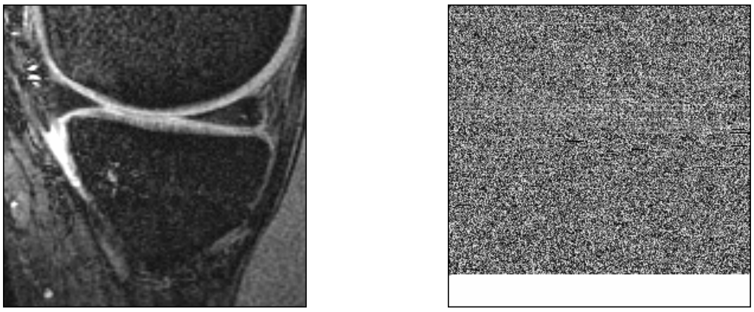

Fig.2. Image 2 and its half-byte format

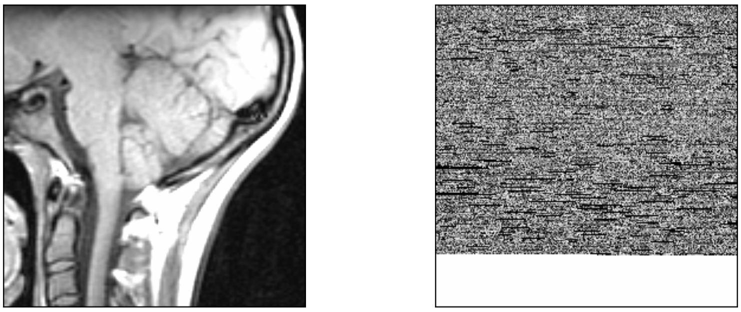

Fig.3. Image 3 and its half-byte format

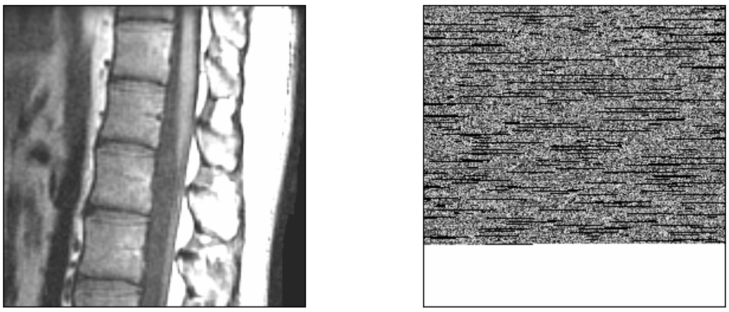

Fig.4. Image 4 and its half-byte format

The all evaluation formats are presented as the BMP images with resolution of 256 x 256 pixels. Thus the size of the test images were 66,6 kilobytes. The smallest output files size is obtained by units of 2 x 2 pixels; for Image 1, Image 2 and Image 3. Using blocks of 8 x 8 pixels the Image 4 was written.

Table 1 shows the output half-byte files the sizes creation, for the test images using blocks of 2 x 2 pixels. Table 1 contains, for comparison, also the output files sizes, at GIF format, which was obtained by dictionary compression of the same test images.

Table 1. The output files sizes (in kilobytes)

Test image	**Half-byte format**	**GIF format**
Image 1	55,5	59,7
Image 2	56,6	63,9
Image 3	53,0	62,6
Image 4	52,1	59,9

The compression factors are determined on the base of the results from Table 1. Table 2 contains compression factors of the test images, computed for the half-byte format and GIF format.

Table 2. The test images compression factors

Test image	**Half-byte format**	**GIF format**
Image 1	1,20	1,12
Image 2	1,18	1,04
Image 3	1,26	1,06
Image 4	1,28	1,11

The test image output files size, at the half-byte format, is in the range 52,1-56,6 kilobytes and at GIF format in the range 59,7-63,9 kilobytes.

The compression factors are at the half-byte format in the range of 1,18-1,28 and at GIF format in the range of 1,04-1,12. It is proved that the half-byte format was more effective than the GIF format. The half-byte format improves that the compression effectiveness of so called “nature” images, particularly containing textures.

4. CONCLUSIONS

The lossless image compression of medical images is usually not satisfying. The half-byte conversion, as a method of preliminary transformation of the image pixel values, improves the effectiveness of compression. The half-byte format is intended for the so called “natural” images with textures that is not satisfying in traditional approaches.

The half-byte format proposal improves some compression approaches efficiency, using the other simple algorithms. It can be recommended for various hardware compressors implementation and different parallel processing algorithms.

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