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OPTIMAL INTERPOLATION FILTER FOR REDUCTION OF BLOCK-STRUCTURE OF IMAGES

Optimal interpolation filter for reduction of the artifact of block structure, that appears on the images, compressed by means of discrete cosine conversion is presented. The suggested method efficiently and relatively simply reduces block-structure, without causing distortions of other characteristics of image quality.

Key words: *image, compression, artifacts, block-structure, discrete cosine conversion, image quality, filtration,interpolation, PSNR.*

Actuality

Digital processing of images (DPI) is widely used in telecommunication, radio and hydrolocation systems, seismology, robotics, radioastronomy, medicine, etc. Transition to digital television, wide application of the networks of various designations, including the Internet, also favors the development of the given trend of signals processing.

Nowadays characteristic problem for DPI devices is constant growth of the volume of the information to be processed, higher requirements to the quality of processing, operation in the conditions of law signal/noise ratio. All this stimulates the advent of new methods and more complex algorithms, used in DPI systems. Among them we can distinguish non-linear algorithms of filtration and restoration of images, wavelet processing, as well as systems, constructed on the principles of fuzzy logic, genetic algorithms, neural networks [1]. That is why, the **problem** of image quality improvement remains actual.

Analysis of the previous research

Greater part of methods of image of video information coding are based on division of the image or frame into square blocks with further coding of each block using discrete cosine transformation (DCT). Such method is called block DCT [2, 3]. The size of each block in greater part of case is 8 x 8 pixels, but in some case, the size can be 4 x 4 pixels, 16 x 16 pixels [4, 5, 6]. Block discrete cosine transformation (BDCT) is used in JPEG and MPEG standards and in video coding standards ITU (H.261, H.263) [4]. At the same time, in case of high degree of compression, the results of BDCT lead to visual distortions of the image after coding. One of such distortions is block structure.

According to [3] block structure is vertical and horizontal false contours, that periodically appear on the image, especially on uniform area (where brightness of pixels is similar or almost similar).

Visual system of human being is sensitive to contours, especially to vertical and horizontal, in particular, in uniform areas of image [7]. According to [8] block structure can be considered as high frequency noise, that is less noticeable on the sections of the image with high detalization, but is considerably noticeable on the uniform sections of the image. The problem of block structure is complicated by its non-linear character and high dependence on the behavior of human vision system, which is also non-linear [7].

In [9] and [10] the authors suggested the method aimed at reduction of block structure, using wavelet transformations without applying “threshold methods”. The drawback of this method is the possibility emerging of various additional distortions on the image, for instance, diffuse images, decrease of image sharpness, etc.

Problems set-up

Large volume of research, aimed at efficient solution of block structure **problem** without distortion of other quality characteristics of the compressed image have been performed [6, 11]. In general, various methods, suggested for elimination of this drawback, differ by their efficiency, rate and computational complexity.

That is why, it is **necessary to elaborate** method, that efficiently reduces block structure, has small computational complexity, simple realization and does not cause additional distortions.

Method of block structure reduction

The reduction of block structure is performed using adaptive low-frequency spatial filtration of the compressed image, taking into account the fact, that low-frequency spatial filtration can distort the sharpness of image details and contours. Thus, filtration operations are adapted to local; characteristics of the image. Three observations are taken into account [11]. First, human visual system is more sensitive to block structure in non-sharp regions or uniform regions, than in the regions, containing details of the image and contours (complex regions). Thus, rather strong can be used in these regions. Second, in less uniform regions it is necessary to reduce the force of filtration, and in complex regions it is necessary to use weak filtration in order to maintain the sharpness of image details and contours. Third, while coding of video information filtration in the uniform regions must be applied inside the blocks, as well as on the boundary of blocks [11].

Instead of rather complex filtration, suggested in [8, 11], the following functions, used in [6] and applied in [11] with other aim, are used:

$$h(n)=\begin{cases} a, & n=0,\\ \dfrac{1}{4}, & n=\pm 1,\\ \dfrac{1}{4}-\dfrac{a}{2}, & n=\pm 2. \end{cases} \qquad (1)$$

Function $h(n)$ is “pulse characteristic”, used for filtration. It corresponds to equivalent weighted function $h(x)$, as it is shown in Fig. 1,for three values of a [13]. Let us assume $h(n)=h(x)$ for $x=n$.

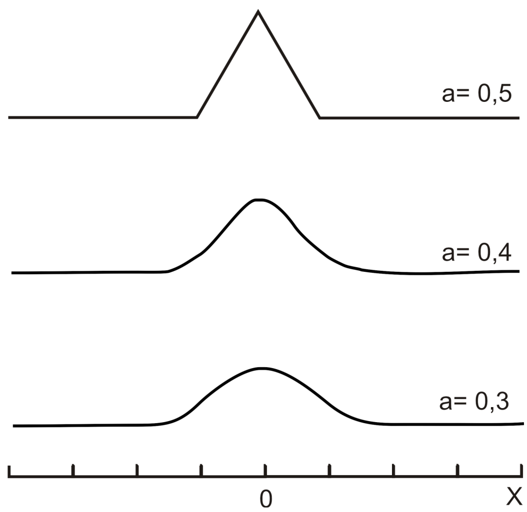

Fig. 1. Equivalent weighted function $h(x)$

Then $h(n)$ is applied vertically for the filtration of horizontal boundaries, using the equation [14]:

$$\begin{aligned} Z_x(x,y) &= h(-2)\cdot z(x-2,y)+h(-1)\cdot z(x-1,y)+h(0)\cdot z(x,y)+\\ &+h(1)\cdot z(x+1,y)+h(2)\cdot z(x+2,y), \end{aligned} \qquad (2)$$

where $z(x, y)$ – is the value of pixel (x, y).

$$Z_y(x, y) = h(-2)\cdot z(x, y-2) + h(-1)\cdot z(x, y-1) + h(0)\cdot z(x, y) + \\ + h(1)\cdot z(x, y+1) + h(2)\cdot z(x, y+2). \tag{3}$$

Regions of the image are classified in accordance with the position of pixels in each block, as it is shown in Fig 2, computing functions, used in [6, 8]:

$$C = \Phi(z0 - z1) + \Phi(z1 - z2) + \Phi(z2 - z3) + \Phi(z4 - z5) + \Phi(z5 - z6) + \Phi(z6 - z7), \tag{4}$$

where $\Phi(\Delta) = 1$, if $|\Delta|$ is less, than threshold *th1*, and $\Phi(\Delta) = 0$ in another case. The value *th1* = 3. The value of $\Phi(\Delta)$ for $\Delta = z4 - z3$ is not determined in the equation (4), because it corresponds to pixels $z3$ та $z4$, which are located on the boundary of blocks.

Function *C* corresponds to "uniformity" of the local region of the image around the boundary of block [8, 11]. Let us divide the regions of the image into the uniform, almost uniform and complex regions according to the following rules:

1. If the value *C* equals 5 or 6, the boundary is located in the uniform or very smoothed region. Pixels *z1* to *z6* are filtrated (Fig. 2). Strong filtration is applied for pixels *z3* and *z*, using function $h(n)$ with a = 0,3. Moderate filtration is used for pixels *z2* and *z5* applying the function $h(n)$ with a = 0,4. Weak filtration is used for *z1* and *z6*, applying function $h(n)$ with a = 0,5.

2. If the value of *C* equals 2, 3 or 4, the boundary is considered to be almost uniform. Pixels from *z2* to *z 5* are filtrated. Function $h(n)$ with a = 0,4 is used for pixels *z3* and *z4*, applying the function $h(n)$ with a = 0,5 for pixels *z2* and *z5*.

3. If the value of *C* equals 0 or 1, the boundary is considered to be complex [11]. Weak filtarion, using the function $h(n)$ with a = 0,5 is applied for pixels *z3* and *z4*.

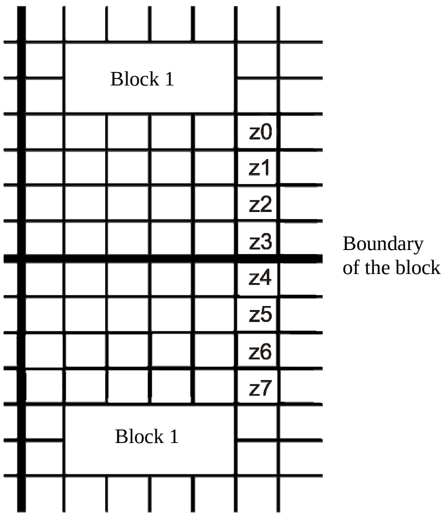

Fig. 2. Example of pixels positions

To improve the operation rate of the method it is suggested to use the following algorithm applying interpolation functions instead the equation (1) (Fig. 3).

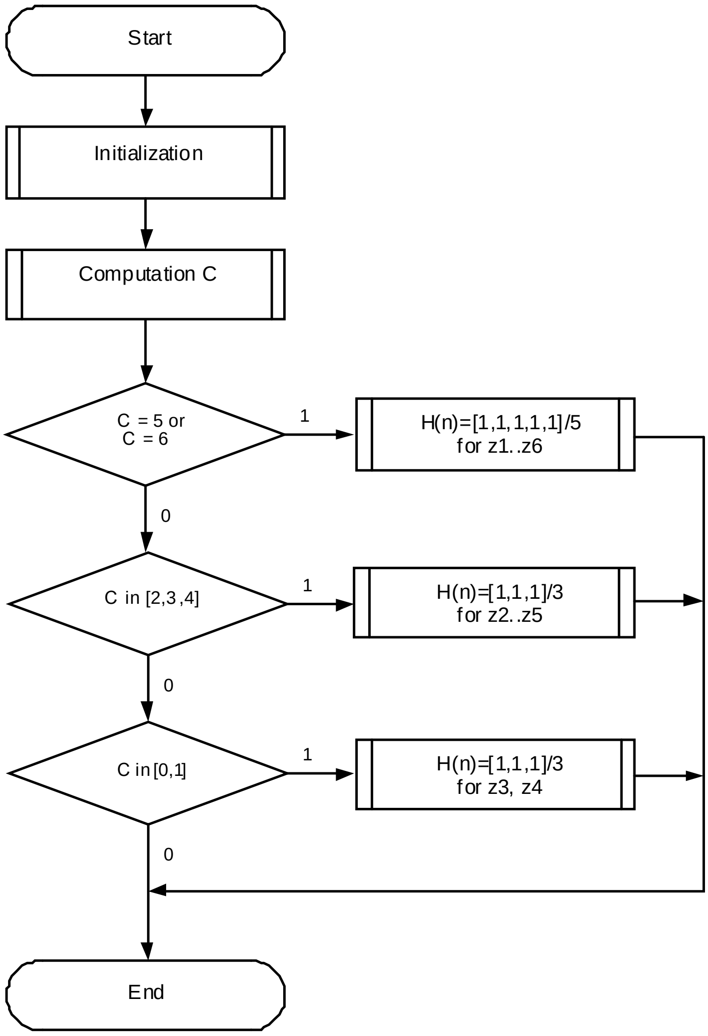

Fig. 3. Filtration algorithm, using interpolation functions

Experimental research

Compressed image with block structure is shown in Fig. 4. Peak signal/noise ratio (PSNR) of the given image is 27,77 dB. Fig. 5 shows the results of image processing by the suggested method. We can observe the improvement of visual quality of the image, processed by the suggested method. PSNR of the processed image is 28, 25 dB.

Table 1 contains PSNR values while applying various methods for five test images

Table 1

PSNR values for various methods

Without processing	Method from [6]	Method from [11]	Suggested method
22,81	23,34	23,21	**23,58**
26,02	**26,85**	26,56	26,81
27,77	28,05	27,90	**28,25**
28,85	29,17	29,09	**29,23**
29,26	29,42	29,32	**29,57**

Fig. 4. Compressed image (PSNR = 27,77 dB)

Fig. 5. Result of the processing using the suggested method (PSNR = 28,25 dB)

Conclusions

Rather simple and efficient method, using adaptive filtration and adaptive interpolation is suggested. The efficiency of the suggested method is better if the level of compression is higher. The values of PSNR, obtained by means of the suggested adaptive method, are better in most cases, than the values, obtained in [6], and are for more better, than the values, obtained in [11] (see Table 1).

In general, the results, obtained by the suggested method, demonstrate high efficiency of the algorithm, taking into account relatively small computational complexity (for instance, as compared with the method of filtration in [8]), that is important for usage in real time applications.

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