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Image Squeezing By The Wavelet Squeezing

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Abstract— ***the problem of effective compression and transmission of images remains one of the most important in the field of multimedia technologies and is very promising in recent years. The article attempts to give its own interpretation of this problem and to analyze the features of the existing methods of wavelet transform, as well as to present software designed for compression of images for their compact storage and transmission through communication channels at maximum speed.***

Keywords: wavelet compression, compression algorithm, image compression, compression ratio, Fourier transform, Daubechies wavelets.

I. INTRODUCTION

The compression technique implies the existence of two algorithms:

1) compression algorithm;
2) decompression algorithm.

It is believed that the compression algorithm and the decompression algorithm are represented as a single unit and called compression algorithm.

In accordance with the requirements for the restoration of the original set, compression algorithms can be divided into two large classes – lossless coding algorithms and lossy coding algorithms. At the same time, algorithms of coding with loss of information can achieve a much higher compression ratio than algorithms of coding without loss.

Lossless coding means the transmission of information without any loss during the data processing, i.e. if the data has been processed by a lossless coding algorithm, it can be restored from the processed data in its original form. In General, lossless encoding is used for “discrete” data such as text, calculation data, some images, etc.

Lossy compression involves the loss of information, so that data that has been processed by this kind of algorithms cannot be recovered or reconstructed exactly (in full compliance with the original). The main requirement for image processing is the absence of obvious evidence that irritates the eyes, thus the use of algorithms with loss of information is allowed for image processing [8]. The next step after data recovery is to measure the quality of the recovered image. Since the scope of algorithms is large, different schemes can be used to assess the quality of recovery.

Compression algorithms can be evaluated by several criteria: its complexity, the amount of memory required to perform the task, how fast it runs on a given computer, or how well the recovered data matches the original. In the

context of this article we are talking about reducing the amount of memory.

II. MATHEMATICAL METHODS OF IMAGE ANALYSIS

The standard Fourier transform is a very popular tool used in spectral signal analysis. As a result of the Fourier transform, the signal is converted into a complex-valued frequency function, which shows how "many" of a particular harmonic in a given signal. Such a method can be of interest for visual analysis only if the signal is stationary - that is, its spectral components do not undergo significant changes in time. Static images are a two-dimensional signal, which is represented in digitized and sampled form as an array of points (colors and their brightness). To compress images, use the fact that the presence of small details is very small. So, the algorithm of JPEG compression to find the little insignificant details using discrete cosine transform [5] (similar to the discrete Fourier transform). High-frequency harmonics, which represent the fine details of the original image, recline from the obtained spectrum. This method of encoding provides high compression rates, but the subsequent restoration of the image from the compressed state of the image is significantly distorted, especially in areas of sharp inhomogeneities. This is due to the use of harmonic functions for the basis of the signal decomposition, since these functions do not decay over the entire transformation plane. This leads to such distortions in the form of waves diverging from the local inhomogeneity of the image. In the case of a non-stationary signal, the Fourier transform yields rather poorly interpreted results. Fourier analysis of such signals gives only a list of its characteristic frequencies (scales), but does not contain any information about the local coordinates at which these frequencies manifest themselves. To date, there is a great interest in the recently appeared mathematical apparatus, which allows to perform the decomposition of functions in a compact, well-localized in time and frequency, orthogonal bases for linear time. This device allows to describe, in contrast to the Fourier transform, unsteady signals, and found application in many applications. The rapid development of this theme began after the publication of the work of I. Daubechies [1], which described a method of finding such bases with predetermined properties.

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Wavelet means functions shifts and extensions of which form the basis of many important spaces, including $L^2(R)$. These functions are compact in both the time and frequency domain. Wavelet transform is directly related to multiscale signal analysis [4].

The application of the wavelet transform enabled us to significantly expand the possibilities of digital processing of nonstationary signals, to develop efficient algorithms for compression and noise reduction of signals. The JPEG2000 image compression standard is based on wavelet transform. This method is widely used in signal recognition and image processing.

The wavelet transform makes it possible to overcome to some extent the above disadvantages of the Fourier transform, since it uses as a basis the time-localized soliton-like functions, i.e. functions with finite energy (norm):

$$E_\varphi = \int_{-\infty}^{\infty} |\varphi(t)|^2 \, dt < \infty$$

Thus, the wavelet transform consists in decomposition on the basis of the above function. As for the Fourier transform, one function is used to construct the wavelet basis- the mother wavelet. The signal function $f(t)$ can be described as follows::

$$f(t) = c_0\phi(t) + \sum_{j=1}^{N} \sum_{k=0}^{2^j-1} c_{jk}\varphi_{jk}(t)$$

Here $\phi(t)$ — mother wavelet. The functions are obtained from the mother wavelet by applying compression and shift operations to the mother wavelet:

$$\varphi_{jk} = 2^{j/2}\phi(2^j t - k)$$

In this case, the time compression is performed in 2^j times and the shift of the resulting function to $2^{-j}k$

The main properties of the wavelet are:

1) final energy (norm);

2) localization in time (space). The faster the wavelet packet attenuates, the better, since the signal analysis area is localized [3, 4];

3) another important property of the wavelet is its alternating sign.

More detailed information about the mathematical foundations of wavelet analysis can be obtained from [1-4, 6].

III. THE USE OF DAUBECHIES WAVELETS IN COMPRESSING IMAGES

Wavelet transform performs image preprocessing, after which the efficiency of conventional compression methods increases dramatically. Consequently, in the process of image wavelet transformations, the sequence of colors (or brightness) is changed in such a way that in this sequence there are as many consecutive identical values (usually zero), which are indicated by black.

The full reconstruction of the signal can be applied only to orthogonal wavelets, in turn, Ingrid Daubechies suggested to use the functions computed by iteration, subsequently called the Daubechies wavelets. They have the following properties: orthogonality, compact support 345 (i.e., the average value of the function is zero and the function decreases rapidly at infinity), and these functions n+2 times cross the abscissa axis. In this case, n is called the wavelet order. For rice. 1 shows three vectors of coefficients of the Daubechies (db2, db4 and db8) and spectra of the coefficients [7].

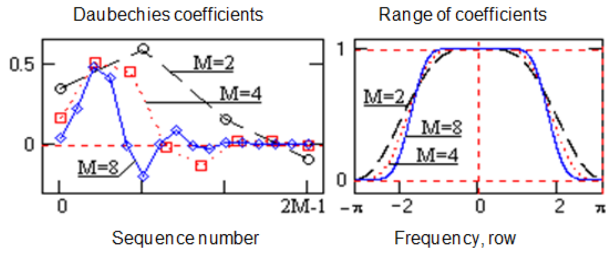

Figure 1. Three vectors of coefficients of the Daubechies (db2, db4 and db8), and their spectra.

As can be seen from the figure, as the order of vectors increases, the slope of their frequency characteristics increases, and, accordingly, the quality of signal decomposition and reconstruction will also improve [1]. This is clearly seen in Fig. 2 and 3, which are the result of the wavelet transform based on Daubechies developed in the framework of this article the software.

For rice. 2 shows the compression of the original image size 1138 KB based on the Daubechies wavelet with a factor 4, in which the compressed file is made up 652 KB.

Figure 2. Image compression based on Daubechies wavelet with a factor of 4.

And figure 3 shows the compression of the same original image based on the Daubechies wavelet by a factor of 6, in which the compressed file was 505 KB.

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Figure 3. Compression of the image based on the Daubechies wavelet by a factor of 6.

The black areas in the image of the wavelet transform are sets of zero values that will be easily compressed by any method of archiving.

With increasing order of Daubechies wavelet increases the "smoothness" of a wavelet, which increases its capabilities, but it also increases the amount of computation when converting. That is, the higher the compression ratio (in this case it is 6), the smaller the size of the compressed file, but more time for calculations.

IV. PROGRAM FOR WAVELET IMAGE COMPRESSION & RESULTS

Within the framework of this article the software designed for compression of images for their compact storage and transmission through communication channels with maximum speed is developed. The presented software has the following characteristics:

• provides the ability to apply different wavelet transforms to the same image set at the same time;

• provides the ability to use a potentially unlimited number of wavelet transforms;

• provides the ability to display both loaded images and conversion results;has a user-friendly interface (Fig. 4).

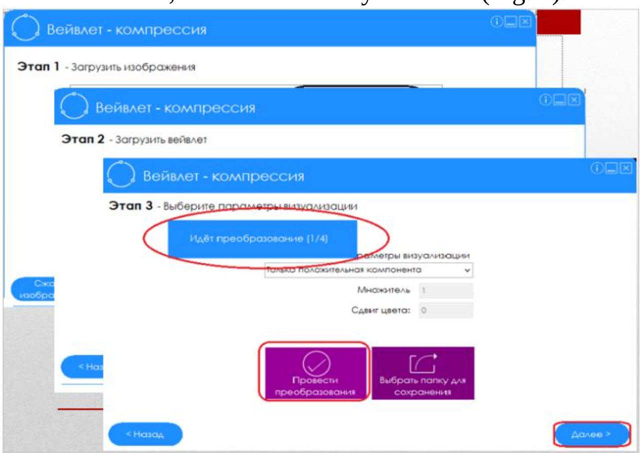

Figure 4. Program interface for wavelet image compression.

V. CONCLUSION

The algorithm of image compression using the daubechy wavelet transform has the following advantages: with large compression ratios, the image becomes smoother, which is perceived by the human eye much better than the block structure; this makes it possible to gradually view the image in the process of downloading over the network; the higher the compression ratio, the smaller the volume of the compressed file, but more time for calculations.

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