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Halyna SOKOL
National Technical University «Kharkiv Polytechnic Institute»
ORCID ID: 0000-0003-4847-518X
e-mail: Sokolgalina@ukr.net
Artem KULHAVIJ
National University Yuri Kondratyuk Poltava Polytechnic
e-mail: artem.kulgaviy97@gmail.com
Serhii TUR
National University Yuri Kondratyuk Poltava Polytechnic
e-mail: sergiotur30@gmail.com
Dmytro TELESHUN
National University Yuri Kondratyuk Poltava Polytechnic
e-mail: dimoniks99@gmail.com

MULTIDIMENSIONAL SIGNALS COMPRESSION ALGORITHM DEVELOPMENT USING WAVELET TRANSFORMS

The paper considers algorithms for compressing multidimensional signals using wavelet transforms, aimed at increasing the degree of information compression, compared with existing compression methods.

Software for compressing multidimensional signals has been developed and the general capabilities of a software product that allows image compression using wavelet transforms are presented.

Keywords: *Wavelet transform, image compression, compression ratio.*

Галина СОКОЛ
Національний технічний університет «Харківський політехнічний інститут»
Артем КУЛЬГАВИЙ,
Сергій ТУР,
Дмитро ТЕЛЕШУН
Національний університет «Полтавська політехніка імені Юрія Кондратюка»

РОЗРОБКА АЛГОРИТМУ СТИСНЕННЯ БАГАТОВИМІРНИХ СИГНАЛІВ З ВИКОРИСТАННЯМ ВЕЙВЛЕТ-ПЕРЕТВОРЕНЬ

В роботі розглянуто алгоритми стиснення багатовимірних сигналів з використанням вейвлет-перетворень, що спрямовані на забезпечення збільшення ступеня стиснення інформації, в порівнянні з існуючими методами стиснення.

Розроблено програмне забезпечення для стиснення багатовимірних сигналів та наведені загальні можливості програмного продукту, який дозволяє проводити стиск зображень з використанням вейвлет-перетворень.

Ключові слова: *Вейвлет переьворення, стиснення зображень, коефіцієнт стиснення.*

Statement of the problem in general form and it’s connection with important scientific or practical tasks

The increase in the amount of information transmitted, video information in particular, affects the operation quality of automated information processing and control systems (AIPCS). The quality and efficiency of the AIPCS function decreases due to the increased load on the communication channels. In automated systems that operate in real time, for high-quality digital image transmission, it is necessary to increase the information transmission speed (increase the communication channels bandwidth), which requires significant financial costs. One way to solve this problem is to use image compression methods in information networks. In recent years, there has been an increase in the number of software products (SOFTWARE) that use image compression methods. These methods play an important role in AIPCS, which includes subsystems for image storage and processing (for example, in forensics and law; in biomedicine and microbiology; in printing; in the radar and infrared images processing in land mapping, sounding; space and military affairs, etc.).

Thus, the task of developing methods of image compression using wavelet transforms, aimed at increasing the degree of compression of information, compared with existing methods is quite relevant.

Algorithm development

Wavelet compression of images is that a wavelet transform is applied to the image, and then some coefficients are removed from the data of the transformed image. Coding can be applied to the remaining coefficients. The compressed image is restored by decoding the coefficients, if necessary, using inverse conversion to the result. It is assumed that in the process of removing part of the conversion factors, not much information is lost.

The process of compressing an image by converting and then deleting some of the information is the basis for understanding wavelet analysis. The literature contains a number of other approaches. Mathematical sources show the development of multi-scale analysis, through the definition of continuous scaling and wavelet functions, but in engineering publications approach this issue through the use of high-frequency and low-frequency filters, as well as quadrature-mirror filter pairs. The Figure 1 shows that these incompatible approaches can be correlated and see that they all lead to the idea of wavelet transform and its treatment [2 -4].

The study of the proposed compression method was performed on images in grayscale 0-255. As a result of experimental studies of Dobeshi bases, the best, in terms of compression ratio base vector was determined, which should be used at the appropriate degree of decomposition 5 db, 2 db, 1 db, 3 db [3].

In General, the proposed algorithm consists of the following steps.

A five-level wavelet transform of the signal is performed using the best Dobeshi basis vector, at each level, respectively:

$$I_w = \underset{i=\overline{1,5}}{dwt}[I_0, \mathrm{bas}_i]$$

where I_0 is the original image, I_w is the result of a five-level wavelet transform, bas_i is the basis used at the i-th stage of the wavelet transform.

The level of visual quality is set with which the image will be restored after decompression by changing the threshold. All wavelet transform coefficients Iw , the modulus of which is less than or equal to a given threshold are reset:

$$I_{w0} = \begin{Bmatrix} I_w, if(I_w > D_0) \\ 0, if(I_w \le D_0) \end{Bmatrix}$$

where D_0 is the threshold that determines the quality level of the compressed image, I_{wo} is the matrix of wavelet decomposition, after zeroing the coefficients.

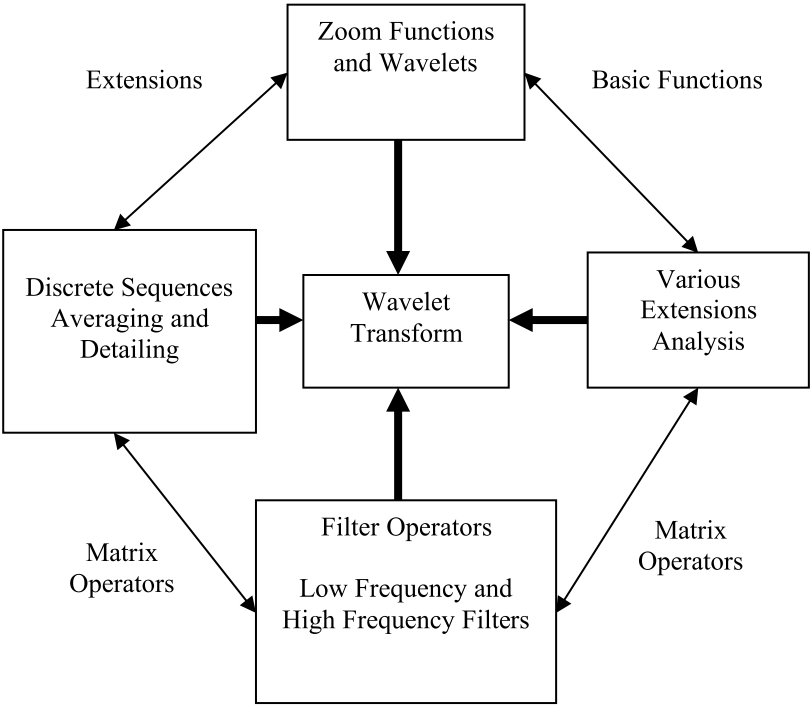

Fig. 1. Block diagram of wavelet transform and its treatment

Conversion of the matrix of coefficients I_{wo} obtained in step 3 into a matrix-string, by sequential reading: application to the obtained string of the algorithm for encoding the lengths of the series. In this case, similarly to the JPEG standard, the most common symbol is 0, because the zero wavelet conversion factors are reset. The coded sequence element is represented as a pair of numbers, where the first number indicates the number of zeros to be inserted after the significant element, and the second number is a significant element.

Applying to the Huffman coding algorithm obtained in step 5, and not the obtained pairs of numbers are analyzed, but each number separately. Huffman's algorithm was chosen because it guarantees a compression ratio greater than or equal to 1, while other lossless data compression methods do not provide such a guarantee [1-3]. The principle of its operation is as follows: the probabilities of occurrence of each symbol of the compressed sequence are analyzed, and the symbols with the greatest probability are assigned a code of the shortest length, thus creating a code table for all symbols of the coded sequence. When using this method of compression, it is necessary to find a compromise between the number of required wavelet schedules and the resulting compression ratio. For this purpose, the dependence of the compression coefficient (K_{cmp}) on the number of decomposition levels N was constructed (Fig. 2).

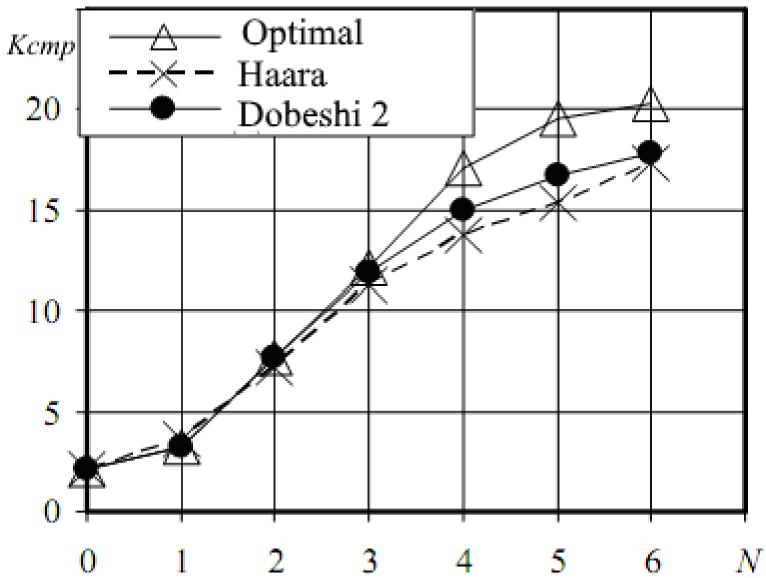

Fig. 2. The K_{cmp} compression dependence on the number of N decomposition levels

The dependence was obtained by averaging 70 monochrome images with a size of 300,300 pixels. From the analysis of this dependence it follows that the use of an optimal basis allows to obtain a higher compression ratio than the use of a fixed basis system at each stage of wavelet decomposition.

Development of a wavelet compression program in the MATLAB environment

Matlab is a package of applications for solving problems of technical calculations and programming languages of the same name, which is used in this package.

Matlab is a high-level interpretive programming language that includes matrix-based data structures, a wide range of functions, an integrated development environment, object-oriented capabilities, and program interfaces written in other programming languages [4,16].

Programs written in MATLAB are of two types – functions and scripts. Functions have input and output arguments, as well as their own workspace for storing intermediate results of calculations and variables. Scripts use a common workspace. Both scripts and functions are not compiled into machine code and are stored as text files. It is also possible to store programs processed in a machine-friendly form. In the general case, such programs run faster than usual, especially if the function contains graphing commands [5, 14, 16].

The main advantage of the Matlab system when using it as an environment for working with images is a diverse set of functions for processing multidimensional numerical arrays, and images (two-dimensional numerical arrays) are an important special case of such objects. The IPT package includes features that extend the capabilities of the Matlab computing environment. These features, as well as the extensive capabilities of the Matlab language, make many complex image processing operations quite accessible; they can be written in a fairly clear and concise form, which makes the Matlab system an almost ideal environment for writing model prototypes of real applications, to solve image processing problems [4, 15, 16].

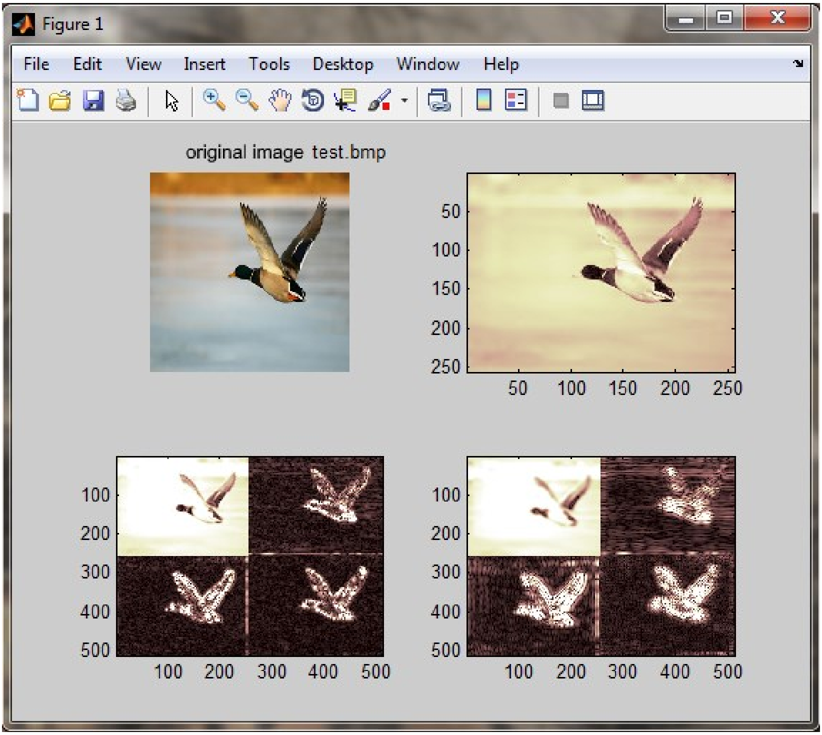

Fig. 3. The results of the transformation in the Matlab environment

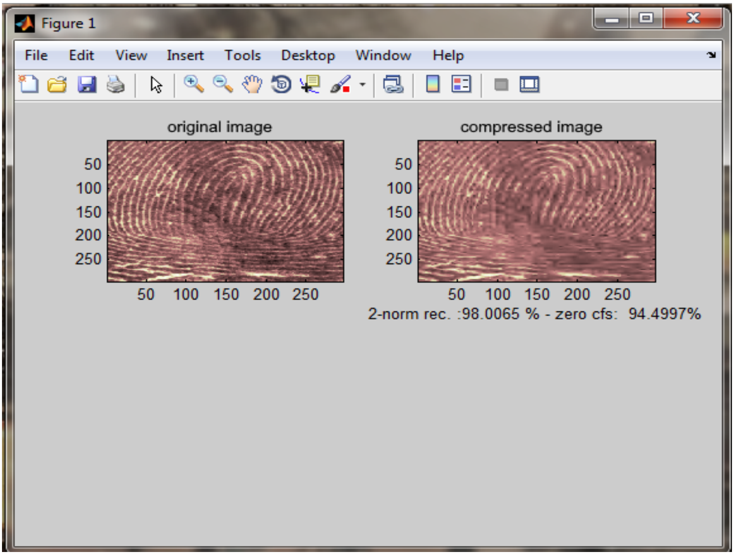

Fig. 4. Example of an original and a compressed images

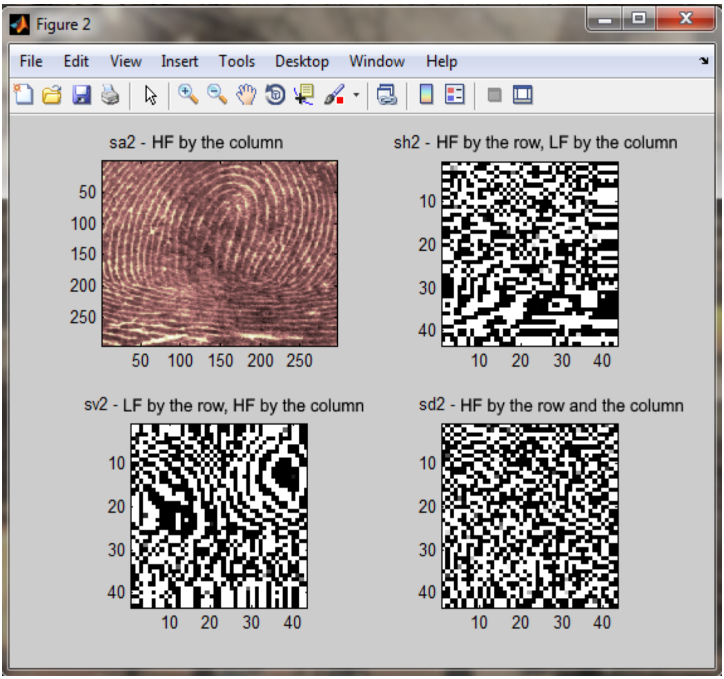

Fig. 5. Examples of image conversion using filtering

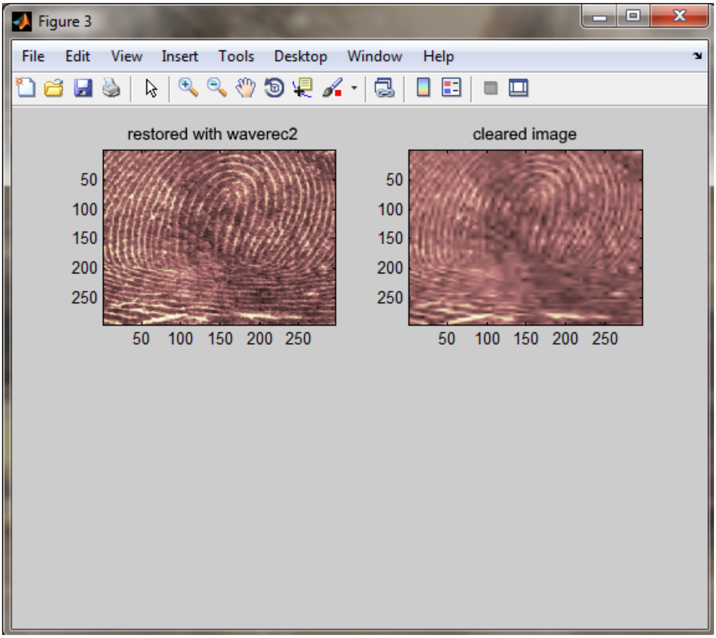

Fig. 6. An example of a restored and a noise-free images

Conclusions from this research and prospects for further developments in this area

The software for multidimensional signal compression is developed in the work. There are also general features of the software product, which allows you to compress images using wavelet transforms.

To study the compression characteristics, the Matlab environment was used, which includes a built-in application package Wavelet Toolbox, which allows you to synthesize all possible algorithms for processing information (data, signals, images) using wavelet functions.

The study found that using the Dobeshi wavelet4 and the depth of image decomposition to the third level, depending on the intensity of the color palette of the image, you can get up to 98% of zero coefficients and the restored energy value of 94% with a slight deviation of visual quality from the original. Using this algorithm allows you to get the image compression ratio up to 50 times.

To compare the Matlab results, a software product was developed in the Delphi environment, which confirms the results of the study.

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