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Application of Discrete Wavelet Transform for Compression Data

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ABSTRACT: Multiple image compression using wavelet techniques, including discrete wavelet transform (DWT) through subband coding (SBC) and decoding, is considered for comparative study. Compression measurement parameters of the true color image, such as compression ratio (CR), Peak Signal to Noise Ratio (PSNR), Mean Square Error (MSE), bits per pixel (BPP), are calculated using the MATLAB software for each algorithm used. A color image selected for wavelet transform to achieve encoding and decoding using several families of wavelets and resolutions to explore their relative strengths and weaknesses. Our main goal is to establish the advantages of several compression methods (compression using multiple resolution), useful when transmitting a large number of compressed images.

KEY WORDS: image compression, discrete wavelet transform, lossy compression, JPEG2000.

I.INTRODUCTION

The widespread use of information technology, computer networks, database technology and their penetration into all aspects of human activity poses the task of storing an ever-growing volume of digital data. Nowadays research and development of methods and algorithms for distributed storage, compression and recovery of data become relevant.

The main part of the digital data is digital images. Therefore, the problem of improving image compression algorithms is very relevant. Effective image compression algorithms are required both to increase image transmission over the network, as well as for efficient storage.

To solve the problem of reducing the volume of digital images, a large number of image compression methods have been developed based on various principles.

All methods require a large number of different requirements: ensuring the target compression ratio, the quality of the reconstructed image, the speed of compression and recovery, the complexity of calculations, protection against losses, and others. Different methods have different applicability and limitations. The problems of compression of a digital image with a high compression ratio and a low level of distortion and estimation of the level of allowable distortion remain relevant. Based on the conducted analytical review of the subject area, a promising direction is the study of compression methods based on the wavelet transform.

II.LITERATURE SURVEY

Since the advent of wavelets as a signal processing tool, much attention has been paid to the use of wavelets for image compression [1, 2, 3].

Using data compression methods, you can remove some redundant information contained in images. The purpose of Image Compression is to minimize the size of the image file without compromising on quality and with the least loss of information contained in it [4].

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Image compression can be lossy compression and lossless compression. [5, 6] In the lossless compression algorithm, compressed data can be used to recreate an exact copy of the original; no information is lost during the compression process. This type of compression is also known as entropy coding. This name comes from the fact that a compressed signal is usually more random than the original; patterns are deleted when the signal is compressed. Although lossless compression is useful for accurate recovery, it usually does not provide high enough compression ratios to be really useful when compressing images.

Lossless image compression is especially useful when archiving images, and also when storing legal or medical documents. Lossless image compression methods include entropy coding, Huffman coding, bit plane coding, run length coding and LZW coding.

In lossy compression, the original signal cannot be accurately reconstructed from the compressed data. The reason is that most of the details of the image can be removed without significantly changing the appearance of the image. When compressing images with losses, although very small details of the images are lost, the image size decreases sharply. Lossy compression, which has significantly higher efficiency, is commonly used to reduce the volume of audio, video, and digital photos like broadcast television, video conferencing, and fax transmission, in which a certain amount of error is acceptable. Lossy compression methods include: fractal compression [16] associated with Fourier [17], DCT (discrete cosine transform), and wavelet transform.

In this article, we will consider and analyze the main methods of image compression based on the wavelet transform. Initially, wavelet analysis was introduced to improve the analysis of seismic signals by moving from short-term Fourier analysis to new improved algorithms for detecting and analyzing sharp changes in the signals of Daubechies [7], Mallat [8], Morle [9] .

There are many wavelets for compressing information. The most popular image compression method used in practice is Discrete Cosine Transform (DCT) [10].

This is a popular conversion used by the standard for image and video compression like JPEG (Joint Photographic Experts Group) [11] for lossy image compression and for MPEG (Motion Picture Expert Group) [14,18]

Recently, wavelet transform has become an advanced technology in the field of image analysis. The wavelet transform [12] provides a significant improvement in image quality at higher compression ratios. Over the past few years, many powerful and complex wavelet circuits for image compression have been developed and implemented. The JPEG 2000 standard is a graphic format that, instead of the discrete cosine transform used in the JPEG format, uses the compression algorithm based on the wavelet transform [13,15].

III. METHODOLOGY

A.Data compression

Data compression is an algorithmic transformation of data that is performed to reduce the amount of data they occupy. It is used to make more efficient use of storage and data transfer devices. The reverse procedure is called data recovery, decompression [2].

Compression is based on eliminating the redundancy contained in the source data. The simplest example of redundancy is the repetition of fragments in the text (for example, the words of a natural or machine language). Such redundancy is usually eliminated by replacing the repeating sequence with a link to an already encoded fragment with an indication of its length. Another type of redundancy is due to the fact that some values in compressed data are more common than others. Reducing the amount of data is achieved by replacing frequently encountered data with short code words, and rare data with long ones (entropy coding). Compressing data that does not have redundancy (for example, a random signal or white noise, encrypted messages) is fundamentally impossible without loss.

Lossless compression allows you to completely restore the original message, because it does not reduce the amount of information in it, despite the reduction in length. Such a possibility arises only if the probability distribution in the message set is not uniform, for example, some of the theoretically possible messages in the previous message encoding are not encountered in practice.

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B. Data Compression Principles

Any compression method is based on a data source model, or rather, a redundancy model. In other words, some a priori information about which data is compressed is used to compress the data. Without such source information, it is impossible to make assumptions about a transformation that would reduce the size of the message. The redundancy model can be static, unchanged for the entire compressible message, or it can be built at the stage of compression (and recovery). Methods that allow you to change the model of redundancy of information based on input data are called adaptive. Non-adaptive are usually highly specialized algorithms used to work with data that have clearly defined and unchanging characteristics. The vast majority of universal compression algorithms are adaptive.

C. Digital images

The main difference between digital and analog images is the discreteness of their presentation. Digital images are presented as a set of discrete elements, the so-called pixels. Each pixel in the image is characterized by a set of attributes: color, transparency, saturation, etc. As a rule, many pixels of a digital image are ordered as a rectangular two-dimensional matrix of size M x N, where M is the number of columns in each row of the image, N is the number of rows of the image. The dimension of the pixel matrix M x N is called the resolution and is an important characteristic of digital images. The matrix of pixels M x N is often called a digital image raster.

D. JPEG 2000 Compression Method.

JPEG 2000 is a graphic format that uses the wavelet transform method instead of the discrete cosine transform used in JPEG format [10, 6].As a result of such compression, the image becomes smoother and sharper, and the file size is smaller compared to JPEG with the same quality. Thanks to the use of wavelet transforms, JPEG 2000 does not have a lack of embedded JPEG.

E. Basis of a signal transformation wavelet

The wavelet transform of signals is a generalization of spectral analysis (Fourier transform). The term "wavelet" (wavelet) in translation from English means "small wave". Wavelets are a common name for families of mathematical functions of a certain form, local in time and frequency, in which all functions are obtained from one generating function by shifting and stretching along the time axis. A wavelet transform is a convolution of a wavelet function with a signal under study, a special type of linear transform. The wavelet functions of the basis allow focusing on specific local features of the analyzed signals, which cannot be detected using traditional Fourier and Laplace transforms [8, 20].

The wavelet transform is divided into two types: discrete (DWT-Discrete Wavelet Transform) and continuous (CWT-Continious Wavelet Transform). Discrete wavelet transform is used to convert and encode signals, continuous - for signal analysis.

Wavelet transforms are widely used, often replacing the usual Fourier transform observed in many areas, including molecular dynamics, quantum mechanics, astrophysics, geophysics, optics, computer graphics and image processing, general signal processing and speech recognition. The main field of application of the wavelet transform is the analysis and processing of signals and functions that are non-stationary in time or inhomogeneous in space. In this analysis task, not only the frequency characteristics of the signal (distribution of signal energy among the frequency components) are important, but also information about the local coordinates at which the frequency components appear or at which rapid changes in the frequency components occur.

IV. EXPERIMENTAL RESULTS

A. Selecting wavelets for compressing an image

Choosing the optimal wavelet framework for image encoding is a complex and difficult to solve problem. A number of criteria are known for constructing “good” wavelets, among which the most important are smoothness, approximation accuracy, size of the definition domain, and frequency filter selectivity. However, the best combination of these properties is unknown.

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As a test image for evaluating compression methods, it is taken from open sources. The image size is 550 by 500 pixels in TrueColor with a color depth of 24 bits 39270 bytes .jpg format (Fig. 1).

Fig.1. Test image

Table1. Images after compression by wavelets haar, db3, db5, bior2.2, bior4.4 level 2

Haar	Db3	Db5	Bior 2.2	Bior4.4
				

Table2. Images after compression by wavelets haar, db3, db5, bior2.2, bior4.4 level 4

Haar	Db3	Db5	Bior 2.2	Bior4.4
				

Table3. Images after compression by wavelets haar, db3, db5, bior2.2, bior4.4 level 6

Haar	Db3	Db5	Bior 2.2	Bior4.4
				

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B. Image quality rating:

A natural way to determine the accuracy of the reconstructed image is to find the difference between the original and reconstructed values. Distortion is evaluated using three parameters.

1. The mean square error of the matrix of pixels of the source and restored images.
$$MSE = \frac{\sum_{M,N}[I_1(m,n) - I_2(m,n)]^2}{M * N}$$
The Matlab package has a built-in function for calculating the root mean square error immse[19]. The lower the error value, the less different the images.
2. S S I M, or the structural similarity index between two images, is determined on the basis of a complete comparison of the original and the obtained images [21].
This characteristic is calculated by the formula:
$$SSIM(x,y) = \frac{(2\mu_x\mu_y + C_1)(2\sigma_{xy} + C_2)}{(\mu_{2x} + \mu_{2y} + C_1)(\sigma_{2x} + \sigma_{2y} + C_2)}$$
3. P S N R, or peak signal to noise ratio, between two images (original and received image). This characteristic is calculated by the formula:
$$PSNR = 10 log_{10}\left(\frac{R^2}{MSE}\right)$$
Since the value of PSNR is of a logarithmic nature, the unit of measurement is decibel (dB).
The lower the error value, the less different the images.

C. Compression table

The results of operation of lossy compression and decoding algorithms for haar, db3, db5, bior4.4, bior2.2 wavelets of all levels are summarized in table4.

Table4. A summary table of compression results

wavelets	number of zeros	mean-squarederror	ssim	psnr	snr
2-haar	93.75	120.7942	0.9513	27.3103	25.2248
4-haar	99.42	227.5488	0.9082	24.5601	22.4745
6-haar	99.55	185.7164	0.9180	25.4423	23.3567
2-db3	93.61	68.4517	0.9688	29.7770	27.6914
4-db3	99.50	271.4609	0.9006	23.7937	21.7081
6-db3	99.77	254.6428	0.8858	24.0715	21.9859
2-db5	93.47	63.4027	0.9702	30.1097	28.0241
4-db5	93.47	353.5937	0.8908	22.6458	20.5602
6-db5	99.81	375.5771	0.8554	22.3838	20.2982
2-bior-2.2	93.61	69.9704	0.9691	29.6817	27.5961
4-bior-2.2	99.45	200.7210	0.9199	25.1049	23.0193
6-bior-2.2	99.73	203.4426	0.9105	25.0464	22.9608
2-bior-4.4	93.47	64.2769	0.9706	30.0503	27.9647
4-bior-4.4	99.43	333.7298	0.8940	22.8969	20.8113
6-bior-4.4	99.84	390.9484	0.8546	22.2096	20.1240

D. Subjective evaluation of compression results

According to a subjective assessment, at small conversion levels up to level 3, all wavelets show equally good results. Visually, the differences become noticeable at conversion levels 6 (Table3).

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Subjective assessment of images obtained by leading methods based on the results of the vector criterion gives a consistent result. A 4-haar image retains more high-frequency detail, 4-db3 gives more blur. Subjectively, 4-haar is better than 4-db3 on a given test image, the best result is shown by the bior2.2 wavelet, the worst result at high levels is the bior4.4 wavelet and db5.

V. CONCLUSION

The article provides an overview of the main methods of wavelet image processing and data compression. An analysis was made of existing methods, algorithms, formats for storing and compressing digital images with and without losses. A review of lossy digital image compression methods based on wavelet analysis is provided.The proposed method is implemented in the Matlab R2015a environment. The main characteristics of the compression method are measured at various parameters.

According to the results of the study, the best results were shown by compression methods: 4 levels of haar, db3, bior-2.2. Subjective assessment of images obtained by leading methods based on the results of the vector criterion gives a consistent result. According to a subjective assessment, at small transformation levels up to 3 inclusive levels, all wavelets show an equally good result. Visually, differences become noticeable at conversion levels of 6 and above. These results can be used to solve image compression problems in medicine, astronomy, satellite imagery and others.

REFERENCES

[1] A. Lewis and G. Knowles, "Image compression using the 2-D wavelet transform", IEEE Trans. Image Processing, Vol.1, pp. 244-250, 1992.

[2] J. M. Shapiro, "Embedded image coding using zerotrees of wavelet coefficients", IEEE Trans. Signal Processing, Vol.41, pp. 3445-3463, 1993.

[3] J. W. Woods and S. O'Neil, "Subband coding of images", IEEE Trans. Acoustics, Speech, and Signal Processing, Vol.34, pp. 1278-1288, 1986.

[4] G .Strang and T. N g u y e n, " W a v e l e t s and Filter B a n k s" , W e l l e s l e y -C a m b r i d g e P r e s s , N e w York, 1996.

[5] M. J. Weinberger, G. Seroussi and G. Sapiro, "The LOCO-I lossless image compression algorithm: Principles and standardization into JPEG-LS", IEEE Trans. on Image Processing, Vol.2, pp. 1309-1324, 2000.

[6] Madhuri A. Joshi, "Digital Image Processing, An Algorithmic Approach", PHI, New Delhi, pp. 175-217, 2006.

[7] Daubechies I, "The wavelet transform, time-frequency localization and signal analysis", IEEE Transformation and Information Theory ,pp. 961-1005, 1990.

[8] Mallat, S., " A wavelet Tour of Signal Processing", Academi Press, New York, 1999.

[9] J. Morlet, "Sampling theory and wave propagation", NATO ASI Series, Issues in Acoustic signal/Image processing and recognition, Berlin, Vol.1, pp. 233-261, 1983

[10] Ahmed, N., Natarajan, T., and Rao, K. R., "Discrete Cosine Transform", IEEE Trans. Computers, Vol. 23, pp. 90-93, 1974.

[11] Pennebaker, W. B. and Mitchell, J. L.,"JPEG, Still Image Data Compression Standards", Van Nostrand Reinhold, 1993.

[12] Vetterli, M. and Kovacevic, J., "Wavelets and Subband Coding", Englewood Cliffs, NJ, Prentice Hall, 1995, http://cm.bell-labs.com/who/jelena/Book/home.html.

[13] ISO/IEC/JTC1/SC29/WG1 N390R, JPEG 2000 Image Coding System, March,1997, http://www.jpeg.org/public/wg1n505.pdf.

[14] K. Sayood, "Introduction to Data Compression", Second edition, Academic Press, 2000.

[15] Livak E.N., "Compression algorithms. Overview of lossy compression algorithms. JPEG2000 algorithm", http://mf.grsu.by/UchProc/livak/po/comprsite/theory_ jpeg2000.html. 21.04.2018.

[16] Stephen Welstead , "Fractal and wavelet image compression techniques", Bellingham, Washington,1999

[17] S. Allen Broughton, Kurt Bryan., "Discrete fourier analysis and wavelets: applications to signal and image processing", USA,2009

[18] K. Rao and J. Hwang, "Techniques and Standards for Image, Video and Audio Coding", Prentice-Hall, 1996.

[19] Dyakonov V., Abramenkova I., "MATLAB. Signal and image processing. Special reference.", St. Petersburg, Peter, pp.608-609, 2002 .

[20] Djananjay Singh., Madhusudan Singh., HakimjonZaynidinov., "Signal Processing Applications Using Multidimensional Polynomial Splines", Springer Briefs in Applied Sciences and Technology Series, Springer, Singapore, ISBN-978-981-13-2238-9. 2019.

[21] Wang Z.,"Image quality assessment: from error visibility to structural similarity", IEEE Transactions image processing, No. 4. pp. 6 0 0 - 6 1, 2004.

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