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THE USE OF WAVELET TRANSFORM FOR IMAGE COMPRESSION

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Evolution of the Internet, increase in computer performance, advances in printers, scanners and digital cameras production technology resulted in a wide usage of digital images. Image quality and size are increasing. File graphical data size is proportional to image pixel count and bits count, needed for every pixel representation. Compression is important for data transition rate and storage efficiency. It is important to improve the image data compression algorithms [1].

Currently algorithms for lossless compression based on multipurpose compression methods and lossy algorithms using graphic data features are being developed. Work on lossy algorithms that can save image quality is going on.

Bitmap image features

Image is a kind of data type that can be characterized by the following features:

- Keeping images requires much more memory than text, which determines image compression algorithms topicality
- Human vision, while analyzing an image, operates with image contours, the general transition of colors and is relatively insensitive to small changes in the image
- An image has redundancy in two dimensions, that is, the neighboring points in the horizontal and vertical directions can be close in color [2].

A bitmap is a two-dimensional array of numbers. The elements of this array are pixels. The main features necessary to display an image are size and depth of color. Size is determined by the width and height of the image in pixels. Color depth is determined by the number of bits per pixel. The higher the color depth is, the wider the range of colors is. Using any color model, each pixel represents the structure with a set of fields, which are components of the color.

Image compression algorithms classification

Existing algorithms for image compression can be classified as follows:

- lossless image compression
  - RLE – Run Length Encoding
  - LZW – Lempel, Ziv and Welch
  - HUFF – Huffman Coding
  - JBIG – Joint Bi-level Experts Group – 1-bit black-and-white image compression
  - Lossless JPEG (Joint Photographic Expert Group) – 8- or 24-bit grayscale image compression
- lossy image compression
  - JPEG (Joint Photographic Expert Group) – 24-bit colorful image compression
  - fractal algorithm – compression with coefficients of iterated function
  - wavelet transform – compression based on the coherence of an image

Image compression algorithm using wavelet transform

Algorithm using wavelet transform consists of two main parts – direct wavelet transform and inverse wavelet transform. The use of direct and inverse transform results in encoding and decoding of graphic image data without any loss. Decrease of nonzero graphic image data occurs after zeroing a part of coefficients after direct transform. Coding data after removal of the wavelet coefficients provides a lossy image compression.

The basic ideas of the wavelet transform

Consider the vector of two points $\{x_1, x_2\}$. These values are replaced by half-sum a and half-difference d: $a = (x_1 + x_2)/2$ and $d = (x_1 - x_2)/2$. Then $\{a, d\}$ is a wavelet transform of the input vector. If d is small, original vector can be represented by the value $\{a\}$, that compresses the stored information. For a larger vector this transform is applied to all pairs in the vector. Next, the transform is applied recursively to the resulting half-sum.

The two-dimensional wavelet transform

The original image can be considered as a one-dimensional array which is then applied by the wavelet transform. In this case, there is a redistribution of the image data. Image data redundancy feature in two dimensions is not used. While applying the wavelet transform to the images we will alternately convert rows and columns of the initial image, and then reduce the considered area twice. At the beginning the region considered corresponds to the image. In the inverse wavelet transform the same sequence is applied to the data in reverse order.

Wavelet transform algorithm

The considered region size must be initialized before the direct transform. In the beginning the considered region size equals the image size. It decreases during the transform. If width and height of the considered area equal to one, then the wavelet transform needs to be finished. If the wavelet transform is applied to all rows of the image, then the considered region is applied to all columns at each iteration. Width and height of the considered region are halved. A matrix of wavelet transform appropriate to the size of the considered region must be constructed. Since the input image can be rectangular, the width and height of the considered region may differ, the matrixes of the wavelet transform must be separately constructed for rows and columns conversion.

Direct wavelet transform can be implemented as recursive or iterative. A detailed diagram of the direct wavelet transform algorithm is presented in Figure 1. The inverse wavelet transform is implemented by using the same procedure in reverse order. The results of the transform with the developed algorithm are shown in Figure 2.

Removal of part of the image information after the wavelet transform

After applying wavelet transform compression must be provided by zeroing part of coefficients. The compression ratio is set by the user as a percentage. Maximum elements must be found from nonzero elements. Thus a user-specified order statistic must be found in a set of graphic data. Images contain a number of channels. An array of image data may contain several thousand items. So search must be effective. It can be done with an order statistic search such as Randomized_Select [3].

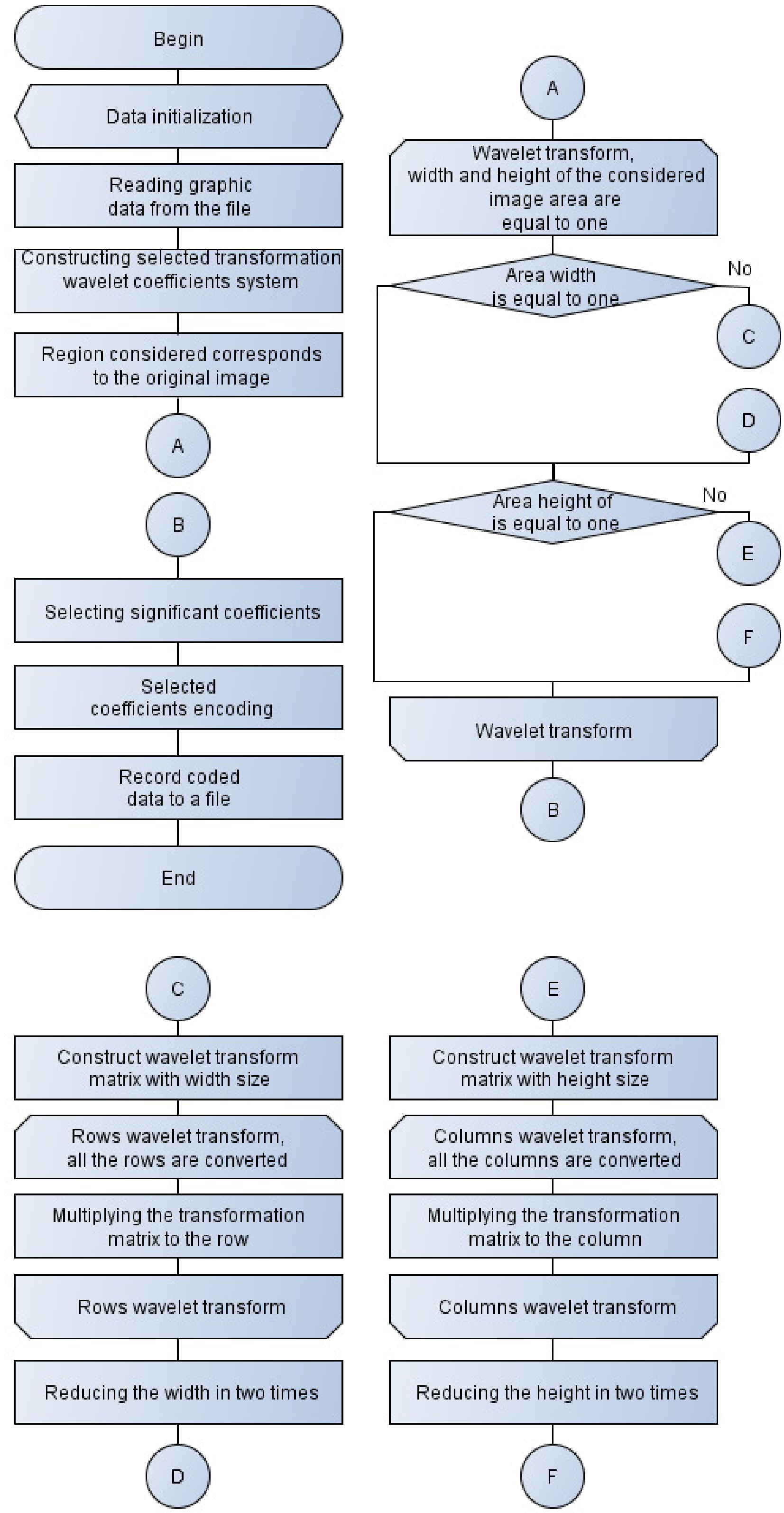

Fig. 1. Diagram of the direct wavelet transform algorithm

Speed is important for both direct and inverse wavelet transform. Since the wavelet transform is multiplying the rows of image data on transform matrix, this operation can be divided into threads. Open standard OpenMP was used for threading. OpenMP tools in Visual

Studio 2010 also simplify its use. OpenMP standard is freeware, has a wide documentation, is constantly updated - these are some of its advantages over other similar tools.

Fi. 2. Wavelet transform of the image «Lena» saving 10% (top right), 5% (bottom left), 2% (bottom right) coefficients. Top left is initial image

Algorithm operating time

The developed algorithm consists of three main parts: direct wavelet transform, inverse wavelet transform, the selection of significant coefficients. Experimental determination of the working time was done for the images with the following sizes 64x64, 128x128, 256x256, 512x512, 1024x1204. The graph of the working time on the image size for direct wavelet transform is shown in Figure 3. The horizontal axis shows the image size in thousands of pixels, the vertical axis represents working time for direct wavelet transform in seconds.

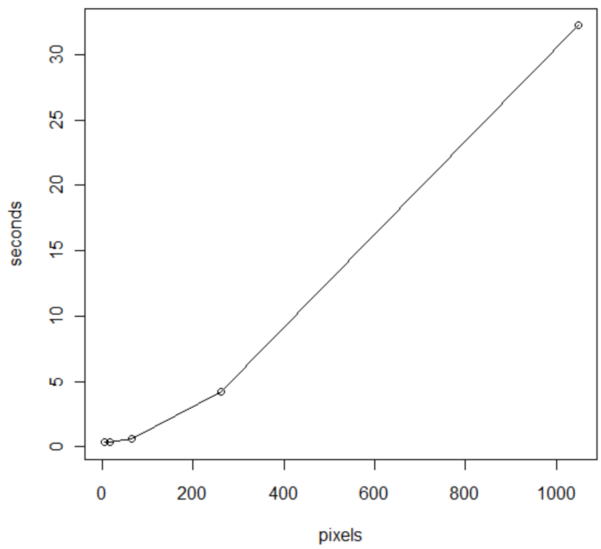

Fig. 3. Graph of the working time on the image size for direct wavelet transform. The horizontal axis is the image size in thousands of pixels, the vertical axis is working time for direct wavelet transform in seconds

The graph of the working time on the image size for inverse wavelet transform is shown in Figure 4. The horizontal axis displays the image size in thousands of pixels, the vertical axis demonstrates working time for inverse wavelet transform in seconds.

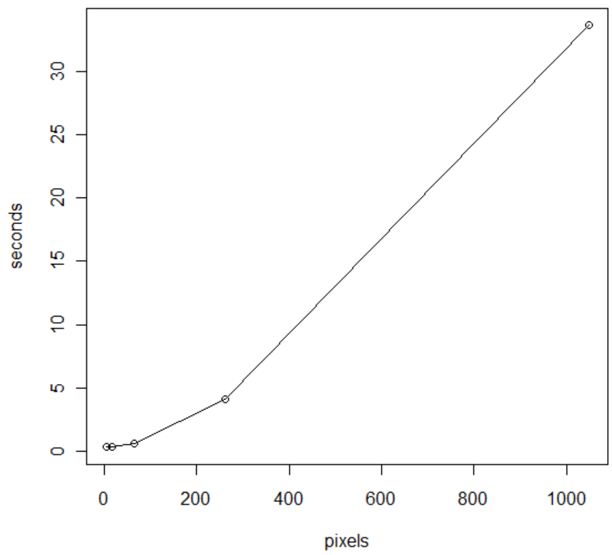

Fig. 4. Graph of the working time on the image size for inverse wavelet transform. The horizontal axis is the image size in thousands of pixels, the vertical axis is working time for inverse wavelet transform in seconds

As seen from the graphs in figures 3 and 4, the working time of the direct and inverse wavelet transform on the image with the size of more than 512x512 is more than 15 seconds. It means that these techniques cannot be applied for the Internet or commercial databases. Developed algorithms require further optimization.

The graph of the working time of order statistic search algorithm on image size is shown in Figure 5. As can be seen from the graph, the algorithm is linearly dependent on the size of the data.

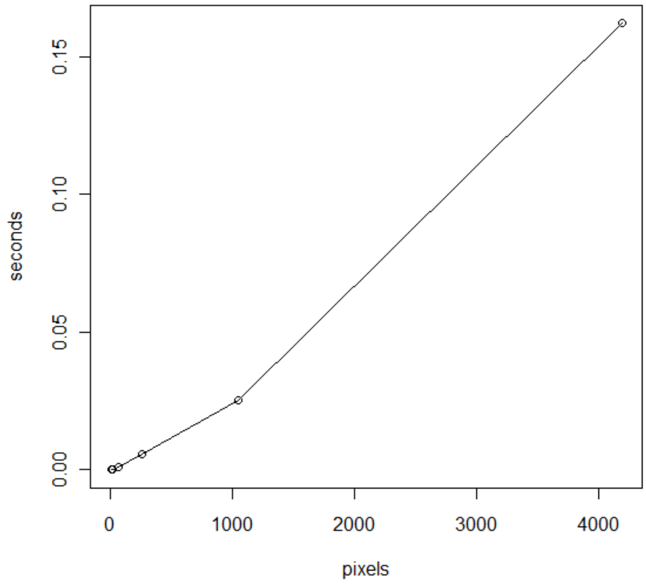

Fig. 5. Graph of the working time of order statistic search algorithm on image size. The horizontal axis is the image size in thousands of pixels, the vertical axis is working time for inverse wavelet transform in seconds

The calculations were performed on a personal computer with the following characteristics:

– Processor: Intel Core 2 Duo CPU T5800 2.00GHz
– Memory size: 2.00 GB

References

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