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DESIGN AND DEVELOPMENT OF SOFTWARE FOR DIGITAL IMAGE COMPRESSION BASED ON DISCRETE HARTLEY TRANSFORM

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Abstract

In the report the effectiveness of the discrete Hartley transform (DHT) to compress image data is substantiated, digital image compression algorithm based on the DHT is considered and its software designed and implemented using object-oriented technology is offered. The report also presents the test results of behaviors of the designed software objects synthesized by the proposed method, which has ensured the full detection of system and algorithmic errors at the design stage of the software.

Анотація

У доповіді обґрунтовується ефективність застосування дискретного перетворення Хартлі (ДПХ) для стиснення графічних даних, розглядається алгоритм компресії цифрових зображень на основі ДПХ та пропонується його програмна реалізація, яка спроектована і реалізована за допомогою об'єктно-орієнтованої технології. Наведено результати тестування проектних моделей поведінки програмних об'єктів, синтезованих запропонованим методом. Це забезпечило виявлення у повній мірі системних й алгоритмічних помилок ще на етапі проектування програмного забезпечення.

Introduction

Massive amounts of data circulate in modern information and telecommunication systems. The vast majority of the processed and transmitted information is graphic: digital images and videos, which are characterized by extra-large volumes. The volumes of this kind of data are constantly increasing. This leads to an overload of data channels, and as a consequence, to a significant increase in the time of information delivery.

The research [1] theoretically and experimentally proves that the time of information and telecommunications system data delivery has a linear dependence on the length of the array of data transferred; the compressed data delivery time and the compression ratio are directly proportional; the compression ratio is directly proportional to the time dispersion of the compressed data delivery. It is also shown that the use of image data compression not only reduces the delivery time, as well as the load on the communication channels, but also lowers the deviation from the average delivery time by reducing the variance.

Therefore, currently, not only the increase of the capacity of modern means of communication, but also the development of a software system to processing of digital images for the purpose of compact representation (compression) is important.

Software of the digital imaging system must be reliable, high-performing, flexible, and should provide an opportunity for improving, scaling, and upbuilding its functionality.

It is possible to ensure these requirements and characteristics through the use of object-oriented approach (OOA). Unlike the traditional approach to development, the OOA makes emphasis on both the information and the software objects' behavior. This leads to creating flexible SS that allow change of behavior and/or information.

However, even the use of the OOA does not prevent errors in the software. And the most important are the errors of software objects' interaction, most of which occur at the design stage. The testing of models is carried out to identify them in the early stages of the life cycle of the system. Sufficient attention is given to the development of tests in the literature, while the creation of test models is not actually considered.

The most promising approach to image processing is the use of mathematical transformations that have high compression properties. One of such orthogonal transformations is the discrete Hartley transform (DHT). Its essence lies in a pair of integral transformations: the forward and reverse, which are using the entered function $\mathrm{cas}(\Theta)=\cos(\Theta)+\sin(\Theta)$, where Θ – variable. The forward and reverse of the DHT function $f(\tau)$ is defined by the following relations [2]:

$$H(\nu)=N^{-1}\sum_{\tau=0}^{N-1}f(\tau)\mathrm{cas}(2\pi\nu\tau/N),$$

$$f(\tau)=\sum_{\nu=0}^{N-1}H(\nu)\mathrm{cas}(2\pi\nu\tau/N),$$

where τ – coordinates of the obtained sequence, ν – coordinates of the target sequence, N – number of the elements.

Compared with other orthogonal transformations, DHT has many advantages and allows receiving transformants with high compression properties. Evaluation of the transformants' values [3] indicates the following benefits of DHT for compression of images:

– the transformant of Hartley transformation allows to overcome the high structural redundancy of the original image;

– the transformant dynamic range is less than the dynamic range of the image samples, the memory of a computer system for storage transform is much smaller than those for storing the original unit of a digital image;

– Hartley transform is invariant to different types of changes;

– the transformant has a rather "smooth" structure, which concludes the effectiveness of DHT filtration and selection coefficients methods.

Thus, based on the algorithms [4, 5] the software consisting of the following procedures is designed and developed:

– division into blocks of input digital image in the BMP file format;

– DHT transformant synthesis for each block;

– filtration of the DHT coefficients DPH in the transformant;

– threshold selection of the DHT coefficients;

– formation of the initial data amounts (compressed image).

The software of digital images compression based on DHT is multicomponent and complex. Also, it must meet several stringent requirements for reliability, high performance, flexibility, survivability, as well as for opportunities to improve, scale, and increase its functionality [6].

So, for a comprehensive consideration of the mentioned features and specifications an object-oriented technology (OOT) for the software development is used. However, even the use of OOT does not provide early detection and, therefore, elimination of system and algorithmic errors in the software, most of which occurs at the design stage of a software system [7, 8]. Because of the substantial redundancy of software that is developed, and a large amount of data circulating between its elements, define essential complexity of the structure of software objects and their interaction. As a result, the number of algorithmic and system errors increases, and thus increases the length of the test checks and the development, as well as implementation and maintenance of the software.

Thus, to identify the algorithmic and system errors in the design phase the testing of the software project models that is developed based on OOT, as well as on the software objects behaviors, is performed [7]. These models describe the interaction between software objects in terms of the program functioning and are created using the proposed method for the synthesis of the software test objects behaviors during the design of object-oriented software. In this case, the tests' run is conducted not on the design models (as behavioral models of software objects

are static), but on the corresponding to them test models, which allow to model the interaction of software objects in their dynamic use.

The software is implemented on a high-level programming language C++ for OS Windows (figure 1).

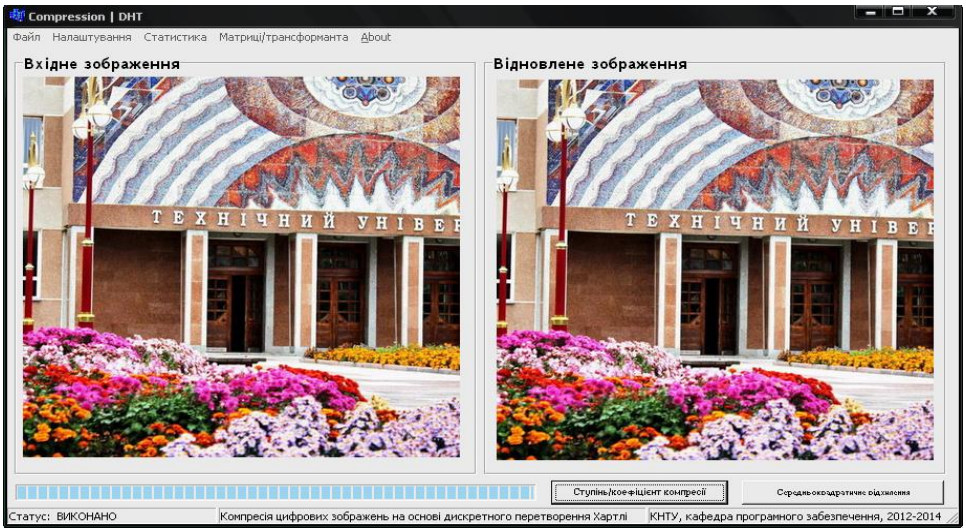

Figure 1 – A DHT-based computer program of digital images compression

The developed software for the compression of digital images based on DHT performs the following functions: compression and restoration of digital images of any dimension; the output of the user-defined original digital image and the output of the digital images reconstructed after the compression (figure 1); calculation of the compression ratio; calculation of the standard deviation; regulation of the threshold values for compression threshold selection procedure; generation of color values in an image block of any range; its' DHT performance, transformant formation.

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