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EWDTS CONTACT INFORMATION

Prof. Vladimir Hahanov
Design Automation Department
Kharkov National University of Radio Electronics,
14 Lenin ave,
Kharkov, 61166, Ukraine.
Tel.: +380 (57)-702-13-26
E-mail: hahanov@kture.kharkov.ua
Web: www.ewdtest.com/conf/

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The main target of the **IEEE East-West Design & Test Symposium** (EWDTS) is to exchange experiences between scientists and technologies of Eastern and Western Europe, as well as North America and other parts of the world, in the field of design, design automation and test of electronic circuits and systems. The symposium is typically held in countries around the Black Sea, the Baltic Sea and Central Asia region. We cordially invite you to participate and submit your contributions to EWDTS'14 which covers (but is not limited to) the following topics:

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The symposium is organized by Kharkov National University of Radio Electronics, National Pedagogical Dragomanov University and Science Academy of Applied Radio Electronics http://anpre.org.ua/ in cooperation with Tallinn University of Technology.

CONTENTS

Video Decompression Technology in Information and Communication Technologies

Yu. Ryabukha, Vladimir Krivonos, Anna Hahanova
Kozhedub Kharkiv Air Force University
Barannik_V_V@mail.ru

Abstract

It is proposed to introduce new methods of video data compression for more efficient use of wireless technology. Therefore, we propose the method of reconstructing digital static images based on the restoration of transforms. There is a technology of renovating values of vector of significant subbands of the nonuniform DCT spectrum on a known code and base; the vector of scaling components based on the decoding of the first zero series and Bodo codes; low-frequency DC component using a statistical code. The decompression method proposed allows restoring an image without making the information loss for a given confidence level.

1. Introduction

An intensive growth of video data, which significantly advance the production capacity of the existing wireless telecommunication systems, generates a need in their compact representation. Existing methods of video data compression, according to the characteristics of the compression ratio, allow transmitting images in real time, however, with a significant loss of quality. One of the areas that can improve the performance of existing wireless technologies in transferring and processing video data is based on the introduction of new methods of compression, which, in turn, will reduce the cost of technical modernization of telecommunication systems. Hence, the development of video coding method to reduce their volume in telecommunication systems is an actual scientific and application task. Therefore, we propose method of compressing video data with controlled quality loss based on JPEG platform [1, 2]. This allows to reduce the amount of information at the desired level of reliability of the image. Image processing starts with changing the RGB color model to YCrCb model, with further segmentation, i.e. partitioning the image into blocks of 8 × 8 pixels. Further, a discrete cosine transform is applied to each block (DCT). Then, quantization and non-uniform decrease of DCT coefficient values are applied to the DCT transform. The next step is the formation of dimensional vector of Y_n component from the transforms using diagonal scanning. A low-frequency DC component is allocated individually from the one-dimensional vector formed, and the vector of significant Y_{n-1} subbands and the vector of scaling G_{n-1} components are formed from the remaining components. Vector of significant subbands is a sequence of non-uniform values of DCT frequency spectrum. Components of the vector G_{n-1} indicate the length of the corresponding sub-band. This method allows gaining an advantage over the JPEG standard, regarding the processing of medium and highly saturated images. In addition, there is a need in reconstructing an image, which won't exceed the complexity of coding and will restore the image without making mistakes.

Hence, the objective of research is to develop a method for the reconstruction of compressed video data using the pre-transformation.

2. Recovery of low-frequency DC component

When applying the DCT to 8 × 8 pixel block, the energy overconcentration occurs, resulting in generation of the low-frequency DC component in the upper left corner of the transform, which is proportional to the average brightness of the entire block. It has a higher value then all other components. All the transform values remaining are called AC components and are proportional to the intensity of the color blends in the block.

Since the value of the low-frequency DC component has a high absolute value, there is a coding of the difference between the current values of the DC

(k) component and the DC (k-1) component of a neighboring preceding block, rather then this DC component, as represented in Figure 1.

$$\Delta DC = DC(k) - DC(k-1)$$

Figure 1. Coding of ΔDC(k) component difference

When recovering the low-frequency DC component, the encoder uses a binary statistical code stored in special code tables . Code of difference of low frequency ΔDC (k) component consists of two parts: master and complement code [3]. The master code $[h_i]_2$ is the code generated statistically which has prefix property and sets the category (range) where the difference is. However, the main code only indicates the order of the difference, therefore a complement code $[q_i]_2$ is used that is generated from the less significant bits of the ΔDC (k) difference values and specifies the category to the exact value of the difference, which is represented by formula

$$[\Delta DC(k)]_2 = [h_i]_2 \cup [q_i]_2 .$$

Recovery of the difference value $[\Delta DC(k)]_2$ is carried out by the tabulated data obtained by decoder on the receiving side that decodes values to the normalized ones instantly and unequivocally.

3. Recovery of vector of significant subbands

Recovery of the sequence of non-uniform values of DCT spectrum significant sub-bands is performed in two stages, which is shown in Fig. 2.

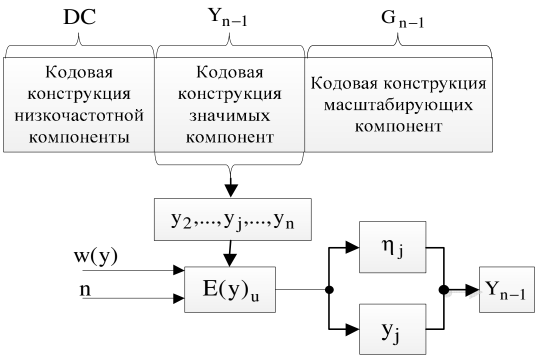

Figure 2. Reconstruction of vector of significant subbands

Where $y_2,...,y_j,...,y_n$ – vector subbands Y_{n-1} excluding the low-frequency DC component; $E(y)_u$ – code structure of the sequence of non-uniform DCT spectrum significant subbands; η_j – an auxiliary value; w(y) – range of vector subbands Y_{n-1}; n – number of subbands in vector Y_{n-1}; j – a subband of the vector Y_{n-1}.

The recovery requires information on the range of subbands $w(y)$, number of subbands n, as well as on zero element of the sequence of non-uniform DCT spectrum, which is defined as $y_0 = w(y)$.

At the first stage, there is a recovery of auxiliary values, having only one limitation $\eta_j < w(y)$, if $j=1$; $\eta_j < (w(y)-1)$, if $j=\overline{2,n}$. Its further recovery is performed using the following formulas:

$$\eta_1 = [E(y)_u / (w(y)-1)^{(n-1)}], \quad (1)$$

$$\eta_j = [E(y)_u / (w(y)-1)^{(n-j)}] - [E(y)_u / (w(y)-1)^{(n-j)+1}](w(y)-1), \quad (2)$$

$$j=\overline{2,n}.$$

where $(w(y)-1)^{(n-j)}$ is a range of the element η_j.

At the second stage, there is a recovery of elements y_j of vector subbands, using the auxiliary values η_j obtained during the previous stage, which is defined by the formula

$$y_j = \begin{cases} \eta_j, & \to \eta_j < y_{j-1}; \\ \eta_j + 1, & \to \eta_j \geq y_{j-1}. \end{cases} \quad (3)$$

Combining the expressions (1) - (3), we shall obtain a system of analytical relations for the recovery of sequence of non-uniform values of the DCT spectrum,

$$y_j = \begin{cases} [E(y)_u / (w(y)-1)^{(n-j)}] - \\ -[E(y)_u / (w(y)-1)^{(n-j)+1}](w(y)-1), \text{при } \eta_j < y_{j-1}; \\ [E(y)_u / (w(y)-1)^{(n-j)}] - \\ -[E(y)_u / (w(y)-1)^{(n-j)+1}](w(y)-1)+1, \text{при } \eta_j \geq y_{j-1}. \end{cases}$$

Here, the recovery of sequence of non-uniform values of the DCT spectrum is provided without making mistakes.

4. Recovery of vector of scaling components

The vector of scaling components consists constructively of three components, which is expressed by the formula $G_{n-1} = \{G_1^{(\ell g)}; G_2; g_m\}$ and is shown in Fig. 3.

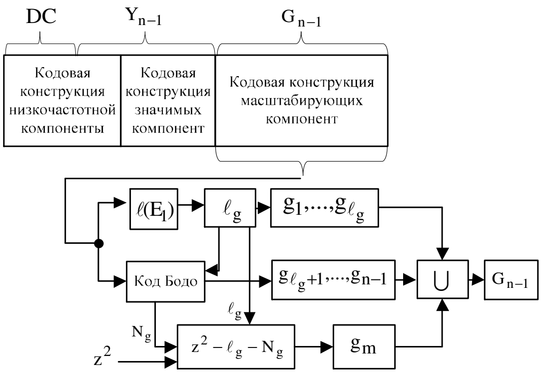

Figure 3. Recovery of scaling components

Where $G_1^{(\ell_g)} = g_1,...,g_{\ell_g}$ - the initial zero series of vector G_{n-1}; $G_2 = g_{\ell_g+1},...,g_{m-1}$ - components, positioned between the series of zeroes; g_m – - the latest series of zero vector G_{n-1}; z^2 – - number of components of the deployed transform; $\ell(E_1)$ – - the first part of the vector code G_{n-1}; N_g – - number of the components in the second part G_2 [4].

Therefore, the reconstruction of the vector of scaling components of the transform is formed from three stages:

The first stage. The first component of the vector of scaling components is reconstructed as a result of reading a decimal number in binary notation $[\ell_g]_2$, namely $[\ell_g]_2 \xrightarrow{\ell(E_1)} \ell_g$, $[\ell_g]_2 = \{\alpha_1,...,\alpha_\xi,...,\alpha_{\ell(E_1)}\}$. This allows obtaining a first component E_1 of the vector G_{n-1}, i.e. $g_j = 0$, $j = \overline{1, \ell_g}$, $E_1 = \{g_1,...,g_j,...,g_{\ell g}\}$.

The second stage. Reconstruction of the second component G_2 is performed by the rule specified by the expressions $P_1(E_2) = \ell(E_1) + 1$, $P_2(E_2) = \ell(E_1) + 1 + d_1$, $P_\xi(E_2) = P_{\xi-1}(E_2) + d_1$. After which, the recovery of the relevant value is performed, $g_\xi = \sum_{\xi=0}^{N_g-1} \alpha_\xi \cdot 2^\xi$. Number of the subbands recovered is determined on the basis of a known length of the sequence of significant subbands of non-uniform DCT spectrum, i.e.

$$N_g = (n-1) - \ell_g .$$

The third phase. The third structural vector parameter g_m is calculated using the formula

$$\sum_{\xi=1}^{n-1} g_\xi = \ell_g + N_g , \quad g_m = (z_1 \cdot z_2) - \ell_g - N_g .$$

Where α_ξ - binary element of the sequence $[\ell_g]_2$; ξ - index of the binary element in $[\ell_g]_2$; P_1, P_2, P_ξ - positions of the components in the component G_2 of the vector G_{n-1}; d_1 - bits needed to represent the components of the second component of the vector G_{m-1} by Baudot code.

An image reconstruction method has been developed, the key difference of which from the existing ones is the use of decoding of values of significant subbands of the sequence of non-uniform DCT spectrum on a known code and base.

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Camera-ready was prepared in Kharkov National University of Radio
Electronics by Dr. Svetlana Chumachenko
Lenin ave, 14, KNURE, Kharkov, 61166, Ukraine

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