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IEEE EAST-WEST DESIGN AND TEST SYMPOSIUM 2012 COMMITTEE

EWDTS 2012 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/

10th IEEE EAST-WEST DESIGN & TEST SYMPOSIUM (EWDTS 2012)

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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'12 which covers (but is not limited to) the following topics:

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The Symposium will take place in Kharkov, Ukraine, one of the biggest scientific and industrial center. Venue of EWDTS 2012 is Kharkov National University of Radioelectronics was founded 81 years ago. It was one of the best University of Soviet Union during 60th - 90th in the field of Radioelectronics. Today University is the leader among technical universities in Ukraine.

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CONTENTS

Coding Tangible Component of Transforms to Provide Accessibility and Integrity of Video Data

V.V. Barannik, A.V. Hahanova, V.N. Krivonos
Air Force University named after Ivan Kozhedub, Kharkov, Ukraine

Abstract

Renders a decision upon further development of compression technologies for transformed images in component representation. Demonstrates description model for transforms tangible components on the basis of positional numbers with unequal adjacent elements. Outlines the basic steps of positional coding to reduce total costs associated with representation of transforms tangible components. To this effect, a system of coding expressions to compress video data accuracy and integrity lossless is developed.

1. Introduction

Problem Statement and literature analysis**.**

The development of modern society has a peculiar feature – dependence on the increased consumption of video data. Thus demanding to provide appropriate requirements for reliability, availability, and integrity of the video data. One of the crucial points when meeting these requirements is video data source coding [1 - 3]. This proves the timely character of relevant scientific and applied research in the field of digital image compression. The analysis of compression systems has shown that the most effective process is provided for pre-transformed images [3 - 5]. However, elimination of redundancy in transforms is carried out mainly by taking into account psycho-visual and statistical laws. As a result, there is a limited level of compression and a sharp drop in reliability of decoded video data. Thus, the objective of the research is to develop the method for coding segment image transforms that will provide increase in availability and integrity of video data for a given level of reliability

2. Description of transforms tangible component using positional numbers

At present, to code transforms in JPEG-oriented technologies they use two basic approaches that differ in the structural approach to transforms consideration [4]. The first approach is based on processing component structure of a transform. The second approach performs coding for the bit-structure of the transform.

Out of two coding strategies, the smallest processing time is provided for the component structure of transforms. This is due to the following reasons:

Bit-structure of transforms is based on binarization of its components. In this case, each component is

formed by binary representation, the length of d bits. As a result, instead of processing $n \times m$ components, it will demand processing d bit planes, each of the $n \times m$ size ($n \times m$ - size of transforms).

The amount of data processed for bit-representation of transforms increases by d times;

- it requires to expend the number of additional operations for the binarization of each transform components;

- the processing for the component structure can be implemented using Huffman code tables. That will require smaller number of operations if compared to arithmetic coding.

Hence, component processing can enforce the condition $q_c + q_r \le \text{argument}(t(q_c + q_r))$ where $t(q_c + q_r) \le q_p / t$.

A distinctive feature of redundancy elimination in the transform component structure lies in:

- concentration of the main energy of the source signal in low-frequency components, and vice versa the data upon small details is formed in high-frequency components of transforms of discrete cosine transformations, the value of which are often close to zero;

- presence of transform component with zero value.

This allows to organize data handling by eliminating statistical and structural redundancy. To this effect, the two-dimensional transform stretches along diagonal zigzag to one-dimensional structure. Then a collective pair is formed $\{y_\alpha, \ell_\alpha\}$, where y_α, ℓ_α is respectively the value of α tangible component of the expanded transform and the number of components having the same value. As a result, n^2 transform component is replaced by m pairs $\{y_\alpha, \ell_\alpha\}$, i.e. $\alpha=\overline{1,m}$. In such manner, the identification of tangible transform components creates the possibility for the elimination of structural redundancy.

The transforms in the course of their description on the basis of structural approach to the Y_m sequence of tangible components have the following peculiarities:

1. Two adjacent components y_ξ and $y_{\xi+1}$ (where $\xi=\overline{1,m}$) have different values, i.e.

$$y_\xi \neq y_{\xi+1}, \quad \xi=\overline{1,m}. \qquad (1)$$

2. If the low-frequency component, i.e. y_1, is excluded from the Y_m vector, the values of tangible components for the Y_{m-1} vector will be in the limited dynamic range, that is:

$$y_{min} \le y_2,...,y_j,...,y_m \le y_{max}. \qquad (2)$$

Here the difference between the value of the upper level y_{max} and the value of the lower level y_{min} of the values range y_j in the interval $2 \le j \le m$ will be less than the dynamic range of the Y_m vector.

To consider the patterns defined by formulas (1) and (2), the approach considering the analysis of the values of tangible components y_j, having the following dynamic range, is proposed,

- For the second component of the Y_{m-1} vector, it will equal $w(y)_2 = y_{max} - y_{min} + 1$, as

$$y_2 \in [0;\ y_{max} - y_{min}]. \qquad (3)$$

- For all other components of the Y_{m-1} vector according to condition (1), it is defined as $w(y)_j = y_{max} - y_{min}$, i.e. reduced by 1, where $j=\overline{3,m}$. This is because the possible values of the y_j component for $j=\overline{3,m}$ will exclude one value that corresponds to the previous component and $y_2 \in [0;\ y_{max} - y_{min} - 1]$.

Thus, on the basis of the proposed transformations for a transform, the Y_m vector of tangible components is formed – its values satisfy the following conditions:

$$y_2 \le w(y)_2 = y_{max} - y_{min} + 1;$$
$$y_j \le w(y)_j = y_{max} - y_{min},$$
$$j=\overline{3,m}. \qquad (4)$$

с неравными соседними элементами (ПЧ) и

In this case, for the Y_{m-1} vector the following interpretation can be produced.

When condition (3) works for the components of Y_{m-1} vector, so that in general $w(y)_j \neq w(y)_v$, $j \neq v$ and $j, v=\overline{2,m}$, the Y_{m-1} vector is the positional number with unequal adjacent elements and the base system $W(y)=\{w(y)_j\}$.

Following this approach considering the representation of the sequence of tangible components, the assessment of information content is reduced to determining the number of admissible PNUAE. In general, for the positional system with mixed base the number of admissible figures equals $\prod_{j=2}^{m} w(y)_j$. Consequently, taking into account the $w(y)_j$ base values relations, we get the following formula for determining the number $V_m^{(y)}$ of admissible PNUAE:

$$V_m^{(y)} = \prod_{j=2}^{m} w(y)_j = (y_{max} - y_{min} + 1)(w(y)_j)^{m-2}.$$

This formula takes into account:

- invariability of the base for the elements of the Y_{m-1} vector;
- inequality of adjacent components of the Y_{m-1} vector.

3. Positional coding of transform tangible components when the adjacent elements are unequal

The positional number with unequal adjacent elements (PNUAE) is formed on the basis of the vector of transform tangible components, by definition.

The formation of the code description should be performed on the basis code constructions for positional numbers. The development of the formula for coding PNUAE is carried out in two stages:

1) The first stage is to determine the value of the code vector, taking into account the transform limited dynamic range (excluding low-frequency component);

2) The second stage develops formulas for the positional number code, taking into account the equality constraint of adjacent components of the Y_{m-1} vector.

Let's consider the first coding stage for the positional number with unequal adjacent elements. The coding of positional numbers as the Y_{m-1} vector of transform tangible components is defined as:

$$E(y)_u = \sum_{j=2}^{m} y_j V(y)_j,$$

where $V(y)_j$ - weight factor of j element of the positional number; y_j - j component of the vector Y_{m-1}.

Since the dynamic range for the elements of the Y_{m-1} vector is equal to $w(y)$,

$V(y)_j = w(y)^{m-j-1}$.

As a result, the value of the positional code $E(y)_u$ will be equal to

$$E(y)_u = \sum_{j=2}^{m} y_j w(y)^{m-j-1} . \quad (5)$$

Equation (4) is to calculate the value of the code for the vector transform tangible components with no conditions of inequality between them. This condition, namely $y_j \neq y_{j+1}$, $j = \overline{2, n}$, is taken into account at the second stage of code regulation development. The ratio to calculate the code of transform tangible components vector, seen as the first positional number with unequal adjacent elements will be the following:

$$E(y)_u = \sum_{j=2}^{m} \Delta V(y)_j .$$

The value $\Delta V(y)_j$ is defined as the number of admissible sequences preceding the $\Delta Y(m-j)$ vector. The value $\Delta V(y)_j$ you is calculated by the following formula:

$$\Delta V(y)_j = \begin{cases} y_j (w(y)-1)^{(m-j-1)} - \Delta V(y'_j = y_{j-1}), \\ \to y_{j-1} < y_j ; \\ y_j (w(y)-1)^{(m-j-1)}, \\ \to y_{j-1} > y_j , \end{cases} \quad (6)$$

where $y_j (w(y)-1)^{(m-j-1)}$ – the total number of sequences (the length is equal to λ_j), for all elements, except the j, which meet the restrictions on the dynamic range and the inequality of the adjacent elements; $\Delta V(y'_j = y_{j-1})$ determines the number of prohibited sequences made up from λ_j elements preceding the coded sequence $\Delta Y(m-j)$.

Let's introduce an auxiliary variable μ_j equal to

$$\mu_j = \begin{cases} y_j , & \to y_j < y_{j-1} ; \\ y_j - 1, & \to y_j > y_{j-1} . \end{cases} \quad (7)$$

As a result, the ratio for the $E(y)_u$ code of the transform tangible components vector will be the following

$$E(y)_u = \sum_{j=2}^{m} \mu_j (w(y)-1)^{(m-j-1)} . \quad (8)$$

In terms of tangible components coding, there are two conditions to be met for the second component:

- no restrictions are imposed on the values of the components prior to the y_2 element with respect to the zero element, i.e. the inequality $y_{j-1} < y_j$ should never be fulfilled;
- the inequality $y'_0 = w(y) > y_2$ is fulfilled.

Therefore, for the component y_2 as the preceding to y'_0, the value $w(y)$ is chosen as the equal to the dynamic range of the vector Y_{m-1}, i.e.

$$y'_0 = w(y) . \quad (9)$$

Thus, the ratios (6) - (8) make it possible to determine the code value for the transform tangible components vector (excluding low-frequency component), which is the positional number with unequal adjacent elements.

In this case, the elimination of sequences containing equal adjacent components, causes elimination of structural redundancy accuracy lossless. Therefore, the elimination of the redundancy is ensured even in those cases, when the dynamic range of transform high-frequency components tend to dynamic range of a low-frequency component, i.e. $y_j \to y_1$.

Let's consider the properties of the positional representation of transform tangible components.

The upper limit of the $E(y)_u$ code for the vector of transform tangible component is the value $\Delta V(Y)_u$ equal to the cumulative $(w(y)-1)^{(m-1)}$ of the elements base of the positional number with unequal adjacent elements, i.e.

$$E(y)_u < \Delta V(Y)_u = (w(y)-1)^{(m-1)},$$

where $(w(y)-1)^{(m-1)}$ - the number of positional numbers with unequal adjacent elements having the following parameters: the dynamic range is equal to $w(y)$, the length of the number is $(m-1)$.

Consequently, the number of digits $\ell og_2 E(y)_u$ allowed for the representation of the value $E(y)_u$, will be limited by $D(y)_u$ from above:

$$\ell og_2 E(y)_u \leq D(y)_u = (m-1) \ell og_2 (w(y)-1) .$$

(10)

Formula (9) provides the definition of the upper limit of costs of binary digit bits to represent the code for the vector of transform tangible components, that has the following parameters $w(y)$ and $(m-1)$.

4. Conclusion

The two-dimensional floating polyadic coding of transforms of the two-dimensional Walsh transformation was developed. The developed representation differs from the already known in the fact that the two-dimensional polyadic coding is performed for the floating number of the transform components of discrete Walsh transform for codograms of uniform length. It provides additional increase in the degree of compression for trasforms of discrete Walsh transform by reducing the excessive number of insignificant digits in code constructions of images compressed representation; and it lets avoid information loss due to the lack of bits in machine word.

1. The approach to constructing the technology for image compression using pre-transformation, based on:

1) formation of two transform components, namely the tangible components vector and the refinement components vector. All this leads to:

- adapt to the structure of the transform, taking into account different concentration of high-frequency components in the image segment and different degree of quantization;

- identify additional structural regularities in transforms of a segmented image.

2) description of the transform tangible components vector as the elements of positional numbers with unequal adjacent elements. This makes it possible to adapt to the properties of linear transforms by taking into account the inequality of values of adjacent components; the limited dynamic range of transforms components;

2. Compression of image segments is done as a result of:

1) elimination of statistical redundancy considering the integrated correlation dependences;

2) reduction of psycho-visual redundancy due to nonlinear quantization of the transforms;

3) reduction of structural redundancy, dependant on:

- identification of transforms refinement components;

- identification of patterns for the vector of transform tangible components, namely, elimination of excessive number of positional numbers that contain equal adjacent elements, consideration of boundedness and irregularity of dynamic range of array elements of aperture lengths.

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