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IMAGE RECONSTRUCTION BY LIFTING FILTERS

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Abstract. In the article describe the estimation of the accuracy of image reconstruction by lifting filters, that in video codecs, the main compression of the video stream is provided by eliminating inter-frame redundancy using motion compensation methods for image fragments of adjacent frames. However, the use of motion compensation methods requires the formation of additional data (metadata) containing information about the types of image blocks used, the coordinates of their movement, etc. At the same time, in order to increase the compression of the video stream without compromising its quality, a higher accuracy of motion compensation is required, which leads to an increase in the number of blocks and, accordingly, to an increase in the volume of metadata that reduces the effectiveness of motion compensation. This is the main problem of compressing streaming video without degrading the quality of images. In addition, the higher accuracy of positioning blocks with motion compensation dramatically reduces the speed of image processing, which is not always feasible in real-time systems.

Keywords: adaptation, the brightness control mechanism, processing dynamic image sequences, reconstruction by lifting filters.

Introduction.

Digital image processing is a rapidly developing field of science. Research and development of methods and algorithms for processing and analyzing information presented in the form of digital images is a very urgent task.

The great contribution to the digital processing of television images was made by both domestic scientists – V.T. Fisenko [3], M.L. Mestetsky [5], V.P. Dvorkovich, A.V. Dvorkovich [1-9], M.K. Chobanu [5-6], V.N. Kozlov [2-7], V.N. Gridin [1-8], V.Yu. Visilter [4], A.L. Priorov [3-4, 9], as well as by L. Shapiro [5-7], R. Gonzalez [1-7], R. Woods [17], G. Finlayson[7-8], C. Wöhler [10], R. Szeliski [6], D. Maier [5, 8].

The number of fundamental studies of Alpatov B.A., Atakishchev O.I., Bashmakov O.E., Bykov P.E., Gurevich S.B., Duda R., Hart P. and others are devoted to the development of methods for detecting and tracking moving objects, image processing and control of objects and purposeful processes. Methods of digital image processing were considered in the works of Gonzalez R., Lukyanitsa A.A., Titov B.C., Filist S.A. Issues related to the transmission of video data were investigated in the works of Zubarev Yu.B., Sogdulaev Yu.S., etc. Methods of recognition of static and dynamic images based on spatio-temporal analysis of video images were covered in the works of Favorskaya M.N., Soifer V.A., Fisenko V.T., Foresight D., Klyuchikov I.A., etc. At the same time, the issues of recognition of moving people (dynamic images) in various situations and in conditions of changing factors (interference, lighting heterogeneity, change of angle, etc.) remain unresolved.

The analysis of the literature has shown that the systems using algorithms of applied television are of the greatest interest. Such systems use the visible part of the electromagnetic spectrum, which is convenient for practical use [2-3]. To date, applied television systems are widely used to perform various kinds of measurement work: diagnostics of the road network [1-2]; detection of pedestrians [2]; detection of obstacles on the runway [2-6]; collision prevention on railways [2-8]; detection of obstacles in front of a mobile ground object [1-5]. All the listed systems using the methods of applied television to perform their task analyze a specific type of obstacle, without solving the problem in the general case. In this regard, a system of applied television based on digital image processing is proposed to solve the problem of detecting obstacles in the room by an autonomous mobile robotic platform, which characterizes in such an obstacle, the system is the main color feature, information, which makes it possible to distinguish the types of underlying surface.

The purpose of the scientific article is to develop models, methods and algorithms for processing complex structured video data based on the use of methods to increase the contrast of television images in video information systems.

Frequency methods of image transformations are based on the idea of the Fourier transform, the meaning of which is to represent the original function as a sum of trigonometric functions of various frequencies multiplied by specified coefficients. An important property is that the function represented by the Fourier transform, after performing transformations on it, can be returned to its original form. This approach allows you to process the function in the frequency domain, and then return to the original form without loss of information. The Fourier transform can also be used to solve image filtering problems. In a practical application, the implementation of frequency approaches can be similar to spatial filtering methods.

Spatial image enhancement techniques are applied to raster images represented as two-dimensional matrices. The principle of spatial algorithms is to apply special operators to each point of the original image. Rectangular or square matrices called masks, kernels or windows act as operators. Most often, the mask is a small two-dimensional array, and improvement methods based on this approach are often called mask processing or mask filtering.

The existing methods of isolating (filtering) significant characteristics of individual image components, some periodic image structures are not optimal from the point of view of Fourier approximation in the specified frequency intervals in which filtering is carried out. Therefore, an urgent problem is the creation of mathematical models and filtering methods that allow for adequate consideration of the energy characteristics of images in selected frequency intervals. The paper develops and theoretically substantiates a method of optimal linear image filtering based on frequency representations, which is optimal in the sense that the spectrum of the image obtained as a result of filtering has the smallest standard deviation from the spectrum of the filtered image in a given two-dimensional frequency subinterval, and outside this subinterval has the smallest deviation from zero.

Usually images are distorted under the influence of various kinds of interference. This complicates both their visual analysis by a specialist and automatic processing using computer technology. Attenuation of the interference effect can be achieved using various image filtering methods. When filtering, the brightness of each point of the source image distorted by interference is replaced by some other brightness value, which is assumed to be distorted to a lesser extent. Such a decision can be made based on the following considerations. The image is represented by a two-dimensional function of spatial coordinates, the values of which change more slowly when moving from point to point of the image than the values of a two-dimensional function describing interference. This allows, when evaluating the value of the useful signal at each point of the image, to take into account a certain set of neighboring points, taking advantage of a certain degree of similarity of the useful signal at these points.

Therefore, in video codecs, the main compression of the video stream is provided by eliminating inter-frame redundancy using motion compensation methods for image fragments of adjacent frames. However, the use of motion compensation methods requires the formation of additional data (metadata) containing information about the types of image blocks used, the coordinates of their movement, etc. At the same time, in order to increase the compression of the video stream without compromising its quality, a higher accuracy of motion compensation is required, which leads to an increase in the number of blocks and, accordingly, to an increase in the volume of metadata that reduces the effectiveness of motion compensation. This is the main problem of compressing streaming video without degrading the quality of images. In addition, the higher accuracy of positioning blocks with motion compensation dramatically reduces the speed of image processing, which is not always feasible in real-time systems. Therefore, MPEG-4-10 codecs use a rectangular block structure of variable size, which provides acceptable image quality at speeds of more than 3 Mbit/s. Thus, the main problem of compressing a video stream without visually degrading the quality of images in real time is a fairly large amount of metadata required to decode compressed images. To date, this problem has not yet been fully solved in world practice.

Additionally, the quality of images is indirectly affected by the amount of compression of audio signals, since both video and sound are transmitted in a single stream at a speed of 2 Mbit/s. At the same time, the volume of audio information, depending on the sound quality, can reach 10-20% of the video. Therefore, we must strive to increase the compression of audio signals. In this regard, the works aimed at improving the methods and algorithms of compression of streaming video and sound, to increase the compression coefficients without a noticeable decrease in the quality of the restored images and sound are of great scientific and practical importance.

Methodology

The analysis of the conducted studies showed that the best in image compression are VF LeGall (5,3), Deslauriers-Dubuc (9,7) and Deslauriers-Dubuc (13,7). But since all the filters considered use integer rounding of the division results, accordingly, with the reverse VP, some distortions of the restored video data occur. Therefore, to assess the accuracy of video data recovery by the considered VFS, a study of their effectiveness in processing 2 artificial and 2 real images presented in Fig.5.19 and 5.20. The efficiency was evaluated based on the calculation of the root-mean-square error (RMS) of the original and reconstructed test images after processing by the LeGall (5,3), Deslauriers-Dubuc (9,7) and Deslauriers-Dubuc (13,7) VFS. According to the results of the experiments, it was found that monochrome images of the type of Fig. 5.19, and all the considered VFS are restored completely, without distortion.

As follows from the research results, the magnitude of the root-mean-square error of restoring test images is mainly determined by the structure of the image itself, and not by the type of the selected VF. Thus, the maximum error (2.9%) occurs when processing a fine-structured mountain landscape, and images with a more homogeneous structure are restored with less distortion, and Deslauriers-Dubuc filters have the best quality characteristics (13.7). However, to build microprocessor video codecs, it is better to use LeGall (5,3) filters, which have 2-3 times higher performance than Deslauriers-Dubuc filters, which allows using a cheaper and more accessible element base. And a small level of introduced distortion, not exceeding a few fractions of a percent, is not perceived by the human eye.

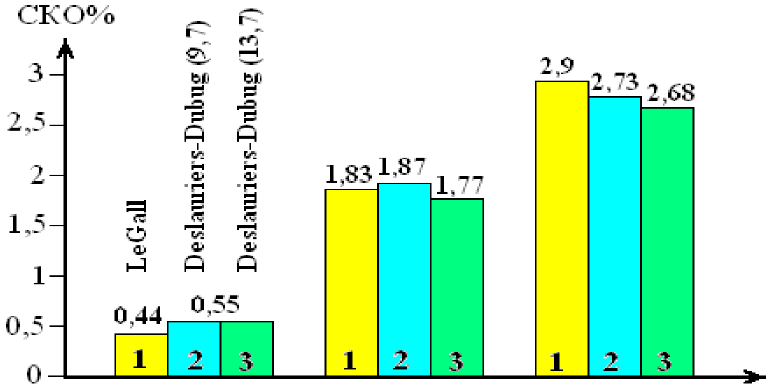


Figure 1. Errors in the recovery of test images after processing

The use of wavelet transformations, as well as DCP in codecs of standards (JPEG and MPEG) does not in itself reduce the volume of video data, but only allows them to be represented as chains of zero values of the coefficients of the decorated pixels. At the same time, video data compression is performed by statistical compressors by packing chains of coefficients with zero values. Thus, the more homogeneous the image was used, the longer the chains of zero coefficients are formed after the VP and, accordingly, a greater compression of the video data volume can be obtained. However, the problem with compression is that the amount of redundant information in an image strongly depends on their plot. Thus, Figure 1 shows examples of compression of images of various subjects without loss of quality [1].

Therefore, quantization is used to control the amount of video data compression, in which the VP coefficients are divided into certain numbers, followed by rounding the result to integer values. This, on the one hand, reduces the dynamic range of coefficients, which require fewer data bits to be stored, and on the other hand, increases the length of zero coefficient chains, which increases the image data compression ratio. However, the structure of these VP coefficients is different than with PREP and represents nested quadrants. So Figure 2 shows the original image and the result of a single VP. To date, an effective mechanism of inseparable VP has not yet been developed, so the transformation is carried out in 2 stages: first horizontally, then vertically. At the same time, 4 regions are formed: containing only low-frequency coefficients - low-frequency, only high–frequency coefficients - high-frequency and overlapping regions containing high-frequency and low-frequency coefficients (Fig. 2). With a larger number of transformations, only the low-frequency region (low-frequency) is processed, and the remaining regions remain unchanged.

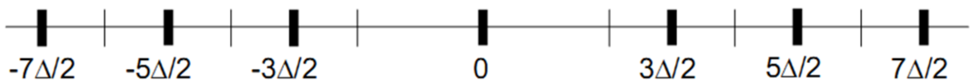
Figure 2. The initial image and the result of a single-level VP

Thus, in the quantizer, the coefficients of the quadrants are divided by a predetermined number, and each wavelet filter has its own coefficients [2].

Most wavelet codecs use scalar quantization. There are two main strategies for performing scalar quantization. If the distribution of coefficients in each band is known in advance, then it is optimal to use Lloyd quantizers - with limited entropy for each subband [3]. In general, we do not have such knowledge, but we can transmit a parametric description of the coefficients by sending additional bits to the decoder. However, in practice, a simpler uniform quantizer with a "dead" zone is often used. Quantization intervals have size Δ, except for the central interval (near zero), whose size is usually chosen 2Δ (Fig.3).

The value of the centroid of this interval is assigned to the coefficient that falls within a certain interval. In the case of asymptotically high coding rates, uniform quantization is optimal. Although in practical modes of operation, quantizers with a "dead" zone are suboptimal, they work almost as well as Lloy-da-Max quantizers, but much simpler in execution [26]. In addition, they are resistant to changes in the distribution of coefficients in the subband. An additional advantage of them is that they can be nested into each other to obtain a nested bit stream [4];

a) uniform quantizer with quantization interval Δ



b) a quantizer with a "dead" zone with a quantization interval of 2Δ.

Figure 3. Variants of quantum converters with uniform and with a "dead" zone

Below in tabular form (table.1-3) the default quantization coefficients for some wavelet filters are given depending on the depth of the VP, which in turn is also a variable number less than or equal to 4 [4].

Table 1. Values of the quantizer matrix for the Legal wavelet filter (5,3)

Level	Orientation	The depths of the discrete wavelet transform (DWT)				
		0	1	2	3	4
0	NN	0	4	4	4	4
1	VN	-	2, 2, 1	2, 2, 1	2, 2, 1	2, 2, 1
2	VN, NV, NN	-	-	4, 4, 2	4, 4, 2	4, 4, 2
3	VN, NV, NN	-	-	-	5, 5, 3	5, 5, 3
4	VN, NV, NN	-	-	-	-	7, 7, 5

*Table 2.*Values of the quantizer matrix for the wavelet filter Deslauriers-Dubuc (13,7)

Level	Orientation	The depths of the discrete wavelet transform (DWT)				
		0	1	2	3	4
0	NN	1	5	5	5	5
1	VN	-	3, 3, 1	3, 3, 1	3, 3, 1	3, 3, 1
2	VN, NV, NN	-	-	4, 4, 1	4, 4, 1	4, 4, 1
3	VN, NV, NN	-	-	-	5, 5, 2	5, 5, 2
4	VN, NV, NN	-	-	-	-	6, 6, 3

*Table 3.*Values of the quantizer matrix for the wavelet filter Daubechies (9,7)

Level	Orientation	The depths of the discrete wavelet transform (DWT)				
		0	1	2	3	4
0	NN	1	3	3	3	3
1	VN	-	1, 1, 1	1, 1, 1	1, 1, 1	1, 1, 1
2	VN, NV, NN	-	-	4, 4, 2	4, 4, 2	4, 4, 2
3	VN, NV, NN	-	-	-	6, 6, 5	6, 6, 5
4	VN, NV, NN	-	-	-	-	9, 9, 7

Results

The brightness control algorithm is designed to correct image defects by applying the formula (1) [1; 15-16-c.].

$$z_n = U_{\theta-1}^{-1}\left(\frac{1}{2}C\right)U_{\theta-n-1}\left(\frac{1}{2}C\right)\left[z_0 + \sum_{k=1}^{n-1} U_{k-1}\left(\frac{1}{2}C\right)(u_k - v_k)\right] + U_{\theta-1}^{-1}\left(\frac{1}{2}C\right)U_{n-1}\left(\frac{1}{2}C\right)\left[z_\theta + \sum_{k=n}^{\theta-1} U_{\theta-k-1}\left(\frac{1}{2}C\right)(u_k - v_k)\right] \quad (1)$$

where: z_0 and z_θ - rows of source data for calculating correction coefficients, they are set directly from the image (these are the first and last rows of the area under study);

$U_{\theta-1}^{-1}$- the inverse matrix of the Chebyshev matrix polynomial in degree $\theta - 1$; $U_{\theta-n-1}^{-1}$- matrix Chebyshev polynomial in degree $\theta - n - 1$; $C -$ the square Jacobiev matrix is a tridiagonal matrix, an argument for calculating Chebyshev polynomials U_n;

U_{k-1} matrix Chebyshev polynomial in degree$k - 1$; u_k and v_k-control parameters in the form of vectors; $n -$ row number in the correction factor matrix for the brightness matrix; $k -$ the current index of the summed array; $\theta -$ a parameter indicating the dimension of all the matrix (brightness, correction) control vectors.

As a result of processing, the required brightness is achieved, which allows you to adjust the brightness of pixels in the selected area of the image due to control coefficients.

In addition, as a result of the algorithm, two results are obtained:

1) The area of the image where the defect was is corrected in accordance with its environment.

2) The control coefficients u and v are calculated for the entire section where the correction is performed. They can be applied to subsequent images with the same defect and its surroundings.

This algorithm uses two basic formulas: $U_{n+2}(x) = 2 * U_{n+2}(x) - U_n(x), n \geq 0,$ $U_0(x) = 1, U_1(x) = 2x,$ (2) where: U_{n+2} - Chebyshev matrix polynomial calculated at the next step (n+2 – degree of the polynomial); U_{n+1} Chebyshev matrix polynomial, which was calculated in the previous step ($n + 2$ – the previous degree of the polynomial); U_n Chebyshev's matrix polynomial, which was calculated two steps before the current one; $x -$ the input parameter on the basis of which the polynomial is calculated $U_{-2}(X) = E,\ U_{-1}(X) = \theta,\ U_0(X) = E,\ U_1(X) = 2X,$ where E – single, and θ – zero matrix.

Thus, by searching for control coefficients u, v, using Chebyshev polynomials of the second kind (1) and (2), it is possible to adjust the brightness in accordance with a given range ($\beta - \varepsilon, \beta + \varepsilon$), where ($\beta$ - minimum brightness, $\varepsilon -$ the difference between maximum and minimum brightness, $z_{i,j}$- the brightness of this point) within the workspace. As a result of the measurement β, ε the brightness range is being set ($\beta - \varepsilon, \beta + \varepsilon$), which should include all points from the workspace after correction. In this case, two additional matrices are created with the size of the selected image area, which are filled with values $U\ and\ V$. Next, the algorithm looks through all the points of the image and calculates the values for each one by iteration $U\ and\ V$, corresponding to the condition, and the values found are then written to the corresponding elements of additional matrices. After all the points are viewed, the process of summing their current values with the calculated ones takes place $U\ and\ V$, i. e.

$$Z''_{i,j} = z_{i,j} + Z'_{i,j}$$

where Z and Z' – matrix of brightness values before and after correction, $U\ and\ V$ - matrices of control values. As a result of this step, the sharpness and clarity of the image increase.

Discussion

By varying these numbers for different conversion levels and different quadrants, you can control the degree of video data loss in the image, thereby changing the compression ratio and the quality of the restored images. At the same time, to ensure the constancy of the bitrate of the compressed video stream, an adaptive change in the values of the quantization coefficients is used, which maintains the constancy of the frame compression ratio when excessive information changes in them. At the same time, the quantization coefficients calculated in the compressor are stored in the output array for proper operation of the decompressor. However, an increase in video data compression leads to an increase in irreversible data loss, which affects the visual quality of the restored images. Therefore, determining the optimal values of the quantizer is a rather difficult task and requires further research.

One of the most urgent tasks in the field of audio-video data processing is the improvement of audio-video data compression methods, taking into account the elimination of temporary redundancy of TV images and audio accompaniment. This problem is very relevant in conditions of limited frequency resources. In addition, it becomes possible to significantly reduce the preparation time for television reports to be broadcast directly from the event sites by transmitting signals from TV cameras directly to the installation hardware of television centers over cellular networks. At the same time, there is no need to use expensive and not always available broadband communication channels.

As a result of the conducted research, TV images have code, intra-frame statistical, psychovisual, structural, temporal or inter-frame redundancy, when eliminated, image information reduction or video data compression is achieved.

Statistical redundancy is eliminated by the use of spectral transformations based on PREP and VP and allows you to compress images by 20-20 times for PREP and 30-40 for VP, and with virtually no data loss.

The presence of psych visual redundancy allows you to control the codec compression ratio by removing that part of useful information that is either not perceived by our visual system, or makes it little noticeable. This approach makes it possible to increase codec compression and, while maintaining visual quality, image compression can be obtained up to 40 times with PREP and 60-70 times with VP. However, with high compression ratios, there are noticeable image distortions in the form of a block structure in PREP or loss of clarity in VP.

The presence of inter-frame redundancy makes it possible to further increase the compression of the video stream to about 80-90 times due to the use of various motion compensation methods. However, these methods for the correct recovery of images during decoding form an additional array of metadata carrying information, but new coordinates of the moved blocks, pointers of block types, etc. Metadata is added to the compressed image data in a single digital stream and must be protected from possible errors, otherwise it will not be possible to restore the image. Moreover, to ensure a higher compression ratio, a more accurate operation of the motion compensator is required by reducing the size of the blocks, changing their geometry or adapting their shape to the configuration of the video objects of the scene (adaptive compensation). However, this leads to a significant increase in the volume of metadata, and accordingly to a decrease in the resulting compression ratio of the video stream, negating all the advantages of motion compensation. Therefore, increased compression can only be achieved by degrading the quality of the images.

Fractal compression methods based on the elimination of structural redundancy can provide the required compression of the video stream by 150-200 times, but they have very low performance and currently cannot provide real-time processing of the video stream.

Thus, to date, existing image processing algorithms can only achieve 130-150 times compression of the video stream due to a noticeable deterioration in their visual quality. Therefore, to ensure good quality of TV images with a frame size of 8-10 kbytes, it is necessary to develop new effective methods for processing video streams that significantly minimize the amount of metadata (no more than 500 bytes per frame), or do not use motion compensation at all.

Conclusion

Experimental evaluation of the efficiency of compression of audio files by fractal and fractal-spectral codec. To evaluate the effectiveness of the proposed method of audio signal compression based on the elimination of temporary redundancy of audio frames, an experimental study of the compression of audio files of various genres with various errors in the identification of audio frames was conducted.

Currently, Haar wavelets are widely used for information compression, which is characterized by simplicity of implementation, since it has only 2 coefficients. However, the Haar wavelet is not very suitable for compressing audio signals, because it does not provide a high degree of compression of the ZS, since when a large number of conversion coefficients are discarded, distortions occur in the form of extraneous noise, crackling and rumbling. To eliminate this disadvantage, higher-order wavelets can be used, for example, Daubeshi-4th order, having 4 coefficients and Daubeshi-10, having 10 coefficients [4,14]. Moreover, the functions of higher-order wavelets have a more "smooth" shape, due to which the compression ratio can be increased while maintaining the sound quality. Therefore, for the implementation of the compression algorithm, it is most advisable to use the Dobshy wavelet of the 10th order, since on the one hand, it provides greater conversion accuracy, and on the other, it does not significantly reduce the processing speed.

References

[1] Artyushenko V.M., Shelukhin O.I., Afonin M.Yu. "Digital compression of video information and sound" I.: Moscow 2003, p. 430.

[2] D. Vatolin, A. Ratushnyak, M. Smirnov, V. Yukin "Data compression methods" http://compression .graphicon.ru/.

D.Salomon. "Data, image and sound compression". // Moscow: Technosphere, 2004 (translated from the English by V. V. Chepyzhov).

[3] V.I.Vorobyov, V.G.Gribunin. "Theory and practice of the wavelet transform". //St. Petersburg: VUS, 1999.

[4] Konstantin Glasman. Video compression. «625» 7/1997. http://rus.625-net.ru/625/1997/07/6.htm.

[5] Otto S. E. Modeling of a digital video signal compression system in real time based on wavelet transformations. Article in the collection of reports of the Republican Scientific and Technical Conference of Young scientists, researchers, undergraduates and students "Problems of information technologies and telecommunications", Tashkent, March 15-16, 2012. I vol. pp.82-83.

[6] R.Gonzalez, R.Woods Digital image processing / Transl. from English-M.: Technosphere, 2006 – 1070 p.

[7] Guzman et al. Digital image processing in information systems-Novosibirsk: NSTU, 2000. - 156 p.

[8] F. Durand and J. Dorsey Fast Bilateral Filtering for the Display of High-Dynamic- Range Images. In John Hughes, editor, SIGGRAPH 2002 Conference Graphics Proceedings, Annual Conference Series // ACM Press/ACM SIGGRAPH 2002 — P. 257—265.

[9] Hirschmiiller, Gehrig S. Stereo Matching in the Presence of Sub-Pixel Calibration Errors // IEEE Conf. on Computer Vision and Pattern Recognition. Miami, Florida, USA. - 2009. - P. 437-444.

[10] H. Hirschmiiller Accurate and efficient stereo processing by semi-global matching and mutual information // IEEE Conf. on Computer Vision and Pattern Recognition. San Diego, California, USA. - 2005. - V. 2. - P. 807-814.

[11] G. Bastin, J. M. Coron and B. d'Andrea Novel, Networks and Heterogeneous Media 4(2), 177-187 (2009).

[12] M. Krstic and A. Smyshlyaev, Advances in Design and Control. Society for Industrial and Applied Mathematics (SIAM) 16, 13-22 (2008).

[13] S., Beknazarova, Latipova, N., Maxmudova, .J., Alekseeva, V.S.. Filtering of digital images by the convolution method/ International Journal of Mechanical Engineering, 2022, 7(1), p. 1182–1191.

[14] Beknazarova, S., Muhamadiyev A. Sh., Iterative methods for solving managed problems of the television image processing / International Conference on IT in Business and Industry (ITBI 2021). Journal of Physics: Conference Series. 2032 (2021) 012002. Omsk-2021.-P.1-10.

РЕКОНСТРУКЦИЯ ИЗОБРАЖЕНИЯ С ПОМОЩЬЮ ФИЛЬТРОВ

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Аннотация. В статье описана оценка точности восстановления изображения с помощью фильтров, в видеокодеках основное сжатие видеопотока обеспечивается за счет устранения межкадровой избыточности с использованием методов компенсации движения для фрагментов изображения соседних кадров. Однако использование методов компенсации движения требует формирования дополнительных данных (метаданных), содержащих информацию о типах используемых блоков изображения, координатах их перемещения и т.д. В то же время, чтобы увеличить сжатие видеопотока без ущерба для его качества, требуется более высокая точность компенсации движения, что приводит к увеличению количества блоков и, соответственно, к увеличению объема метаданных, что снижает эффективность компенсации движения. Это основная проблема сжатия потокового видео без ухудшения качества изображений. Кроме того, более высокая точность позиционирования блоков с компенсацией движения резко снижает скорость обработки изображений, что не всегда возможно в системах реального времени.

Ключевые слова: адаптация, механизм регулировки яркости, обработка динамических последовательностей изображений, реконструкция с помощью подъемных фильтров.