THEORY AND METHODS OF SIGNAL PROCESSING

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COMPRESSION OF DIGITAL IMAGES ON THE BASIS OF MULTILEVEL SPLINE APPROXIMATION

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Abstract*—*Considered the method of spline approximation of television images based on multilevel spline approximation.

Index Terms—Splines; spline approximation; two-dimensional splines; video compression methods.

I. INTRODUCTION

All data compression methods are based on the position that the data flow is always contains redundant elements. Compression is achieved through search and coding redundant elements.

The main difficulty when working with digital video, there are large amounts of disk space required to store even small fragments. Even the use of modern compression algorithms not change the situation radically. When recording on a single CD "everyday" quality to it, you can put a few thousand photos, about 10 hours of music and a half hour video. Video "television" format 720×576 pixels at 25 fps RGB requires a data stream at approximately 240 Mbps (that is, 1.8 GB/min). Thus the compression algorithms oriented to individual frames, do not improve the situation, because even when the flow decrease in 10 times it is quite large.

Stream TV images contains a significant amount of redundant information, which can be eliminated almost no perceptible to the human eye distortions

II. ANALYSIS OF THE LAST RESEARCHES AND PUBLICATIONS

Today has developed effective methods of multidimensional discrete Fourier analysis is the Fourier transform (DFT), discrete cosine transform (DCT). A number of recent works devoted to the generalization of wavelet compression methods television pictures. As a kind of wavelets can be viewed and splines. Splines have a well-developed theory and known good approximation properties in a number of situations have the best approximating properties that provide the minimum possible in the given dimension error operate with simplicity and effectiveness calculations. In their application significantly reduces the amount of calculations.

In [2] is proposed to compress images to use the method of least squares (MLS) regression spline approximation. Obviously, the idea of compression and the approach is close to the wavelet methods, however, there are a number of significant differences.

Single interpolation when compression is replaced by-squares approximation. It allows to increase the compression of low-frequency component on a separate stage in 2 times, and much more (8–32). Virtually eliminates the need for gradual compression. MLS provides a minimum average of the squares of the high-frequency component for the given base, which makes the maximum number of minor counts. MLS provide optimal from the point of view of statistical characteristics, which allows the algorithm to work in the presence of noise.

In [3] considered the combination boatmaster wavelet analysis and Hermitian splines of the third order for image compression. This algorithm is based on the use of decomposition of the signal spline with any frequency. As is known decomposition of a signal by wavelets with multiplicity other than "2"leads to a significant increase in hardware and software costs

III. FORMULATION OF THE PROBLEM

Given the characteristics of the video data, and given the fact that the uncompressed data require to store much more memory than uncompressed determined the relevance algorithms backup television pictures. To implement this task, given the success of compression of individual images, is offered instead of the DCT and wavelet converted to use the spline-approximation of TV images.

IV. SPLINE APPROXIMATION TELEVISION PICTURES

Video processing information necessary to solve problems of approximation of functions of several variables. Let's consider the solution of this problem

for functions of two variables with algorithms for univariate splines. Often, to solve this problem using finite element method, the ideas of which are most similar to the spline methods. One of the challenges of this method is to split nobligan area into sections.

Let him have some of nobligan dependence of two variables $f(x,y)$, which is represented on the site $x \in [a_1,b_1]$, $y \in [a_2,b_2]$ the times at the nodes of a rectangular grid:

$$f_k = f(x_i,y_j),\ i = \overline{0,R},\ j = \overline{0,M},\ k = \overline{0,L}.$$

Will bring $f(x,y)$ two-dimensional spline $S(x,y)$, what is the tensor product of one-dimensional splines $S(x)$ i $S(y)$:

$$S(x,y) = S(x) \otimes S(y).$$

Therefore for the tensor splines R fragments axis x, M axis y:

$$S3d(x,y) = \sum_{i=0}^{R} ax_i\, fx(x) \otimes \sum_{j=0}^{M} ay_j\, fy(y);$$

$$S3d(x,y) = \sum_{j=0}^{M} \sum_{i=0}^{R} a_{i,j}\, f_{i,j}(x,y);$$

$$S3d(x,y) = \sum_{k=0}^{K} a_k\, f_k(x,y);$$

$$\mathbf{S} = \mathbf{F} \otimes \mathbf{A}.$$

Presentation of two-dimensional splines through the tensor product of one-dimensional makes it relatively easy to obtain analytical dependencies and build algorithms based on the known one-dimensional. Their main disadvantage is the inability of local optimization grid and high the degree of the polynomials. Limit their use is the need for regularity of the grid nodes of interpolation.

Next to construct a two-dimensional spline method of least squares, it is necessary to solve a system of normal equations:

$$\mathbf{(Y - FA)^T(Y - FA) = min};$$

$$\mathbf{F^TFA = F^TY};$$

$$\mathbf{A = (F^TF)^{-1}F^TY = C^{-1}B},$$

where **F** is the planning matrix of two-dimensional spline; **Y** is the vector of input values; **A** is the vector of the estimated parameters (*y* nodes "gluing" spline).

Television images of two-dimensional signal dimension or. Although two-dimensional signals and may be processed using one-dimensional systems, in General, prefer the use of two-dimensional systems. Many of the fundamental ideas of one-dimensional processing is easily generalized to the case of two-dimensional processing. At the same time, some rather important concepts related to one-dimensional systems, you cannot directly be used for two-dimensional systems.

Consider the method of constructing two-dimensional spline analysis for compression TV images.

Let the initial data is represented by a matrix $N \times N$ discrete samples. Construction of two-dimensional spline is due to the tensor product of one-dimensional spline functions. However, this procedure takes a long time because of the complexity of matrix multiplication. Because of the multiplication of large matrices requires a lot of operations of multiplication, addition. That's why it can be approximated by splines first data in the rows of the matrix, and then column.

1. Approximation of data by spline to be $N/2$ sites for "gluing" spline. As program point for all the rows.

2. Repeat the procedure for all n the columns. That is, the number of coefficients is reduced from N^2 to $N^2/2$. The spline is constructed so that the sum of squared deviations of the spline from approximated point was minimal

3. Restored full matrix interpolation spline received nodes "gluing" first in columns and then in lines.

4. To store information about errors we find the difference between the initial and new matrix in $N \times N$ points. A significant portion of these differences will be small enough that it was possible to neglect. Sets the threshold below which the value differences are assumed to be zero. A significant number (that is non-zero) detalji coefficients of the first level denote Δ_1.

Then the result of the first step compression $N^2/4 + \Delta_1$ values that are to be kept for possible restoration of the source function.

5. Again similar to approximate the data obtained after the first step. Then instead $N^2/4$ values get $N^2/16 + \Delta_2$. And after the second step have to store $N^2/16 + \Delta_2 + \Delta_1$ coefficients.

6. Accordingly, the third step will give $N^2/64 + \Delta_3 + \Delta_2 + \Delta_1$ values.

After each step, we can immediately restore the original data.

For full recovery of the signal you want to store the nodes gluing last layer schedule and a non-zero counts detail factors.

V. Conclusion

Rearranged algorithm spline approximation television images detailing calculation of the coefficients gives the possibility to improve the quality of decompressing video images or increase the compression ratio for the same quality 5–15 % compared with the wavelet method.

The proposed algorithm has a lot of opportunities to improve computational schemes and parameters. This is the choice of appropriate bases, gradual compression, adaptive compression given the nature of some provinces, etc. Such detailed research and development of specific software implementations beyond the scope of this work out as require separate attention, a significant amount of research and expenses.

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М. О. Шутко, О. Г. Гуйда, А. М. Негода. Стиснення цифрових телевізійних зображень на основі багаторівневої сплайн-апроксимації

Розглянуто метод сплайнової апроксимації телевізійних зображень на основі багаторівневої сплайн-апроксимації.

Ключові слова: сплайни; сплайн-апроксимація; двовимірні сплайни; методи стиснення відео.

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Н. А. Шутко, А. Г. Гуйда, А. Н. Негода. Сжатие цифровых телевизионных изображений на основе многоуровневой сплайн-аппроксимации

Рассмотрен метод сплайновой аппроксимации телевизионных изображений на основе многоуровневой сплайн-аппроксимации.

Ключевые слова: сплайны; сплайн-аппроксимация; двумерные сплайны; методы сжатия видео.

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