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Increase Efficiency of Digital Processing of Signals Based on Spline-Functions

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ABSTRACT: The development of the modern world's information and communication technologies and their implementation in various industries are important, are essential to the creation of parallel algorithms for solving problems of the recovery and digital signal processing, on the basis of the treatment processes a multi-core architecture and the search for optimal solutions. The current stages of development of the structure of machines, complexes and systems installed at facilities that are part of the structure of devices specialized for conducting scientific research or located on rolling stock are characterized by on-line analysis of complex processes and fields and increased demands on the speed of processing large amounts of data in real time.

KEYWORDS: multi-core architecture, splines, differential, polynomial spline, cubic and bicubic spline.

I. INTRODUCTION

The world scientific conducted research works aimed at creating parallel processing algorithms and implementation processes based on multi-core architectures in addressing the challenges of digital processing signal particular, in this respect, in the recovery and analysis of signals commonly used methods of parallel processing techniques and spline - functions splines as the class of piecewise functions are widely used in the creation of software and hardware due to the small amount of computation, flexibility of processing algorithms, optimal differential and extreme properties, simplicity of parameter calculations, little effect on the integrity of errors, operational data processing, increasing the efficiency of digital signal processing algorithms, developing methods, algorithms, hardware and software designed to determine the local features of signals.

II. MODERN METHODS OF DIGITAL SIGNAL PROCESSING

Modern methods of digital signal processing are largely dependent on the algorithm and structural tools, the development of software and the architecture of computing tools.The simplest and most widely used part of the task of restoring the analytical form of functions based on the table data of functions is the question of interpolating these functions.

In classical interpolation, polynomials are constructed in the interval itself [a,b]. The more we increase the nodal points, the better the approximation. However, the degree of the polynomial generated depends on the number of nodal points, increasing the number of nodes increases the coefficient of the polynomial, which complicates the task decennia's systems of algebraic equations of higher order. The possibilities of classical interpolation polynomials are partially limited. Since the number of a system of composed algebraic equations depends on the number of nodal points, the order of systems of algebraic equations also increases. As a result, when constructing classical polynomials, a number of disadvantages arise:

- as interpolations polynomial and has a high degree, then the formula is obtained inconvenient;
- in the process of solving a system of higher-order algebraic equations, certain methodical errors occur;
- the calculation process becomes complicated, as a result a calculation error appears.

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The created polynomial can badly approach a restored polynomial. Therefore, in order to get rid of these shortcomings, the use of interpolation in problems for approximation using spline functions instead of classical polynomials has great potential and is already reflected in science.

Local interpolation splines closely approximate the object to be interpolated and have a simple appearance. The degree of the spline that is being constructed does not depend on the nodal points. The spline function being created is not built on an interval. $[a,b]$, and in the inter $[x_i, x_{i+1}]$ $i=(\overline{0,n-1})$ and this spline function on each interval will consist of polynomials of the same structure.

In classical interpolation on the whole interval $[a,b]$ built one function. Therefore, interpolation using spline functions compared to classical interpolation has a high degree of accuracy and simpler design. Piecewise smooth polynomial functions built on intervals $[x_i, x_{i+1}]$ $(i=\overline{0,n-1})$ called spline n- functions.
Interpolation of functions shows that interpolation by spline functions is more efficient than interpolation by means of classical polynomials.
Actually polynomial interpolation spline function:
1) provides a good approximation to the object;
2) it has a simple construction and is distinguished by its simplicity in the compilation of a computer algorithm.
In practice, we widely use functions of the third degree, that is, cubic splines. In the formula for describing a spline, the value of the spline coefficient is expressed by the nodes of the function and the distance between the nodes (1). For splines with d = 2 ohm defect algorithm s are considered absolutely stable. However, when d = 1 recurrent smoothing splines is not stable. Cubic inline splines are expressed as follows.

$$B3(x) = \begin{cases} 0, & x \geq 2, \\ (2-x)3/6, & 1 \leq x < 2, \\ 1/6(1+3(1-x)+3(1-x)2-3(1-x)3), & 0 \leq x < 1, \\ B3(-x), & x < 0. \end{cases} \qquad (1)$$

x < 0.In fig. 1 shows one basic spline. In fig. 2 shows a complex of cubic basis splines shifted by an unchangeable step h = 1.
For splines of degree 3, local formulas have the following form:
- 3-point formula:
b i = (1/6) (- f i-1 + 8f i - f i + 1);
- 5-point formula:
b i = (1/36) (f i-2 - 10f i-1 + 54f i - 10f i + 1 + f i + 2);
- 7-point formula
$b_i = (1/216)(-f_{i-3} + 12f_{i-2} - 75f_{i-1} + 344f_i - 75f_{i+1} + 12f_{i+2} - f_{i+}$

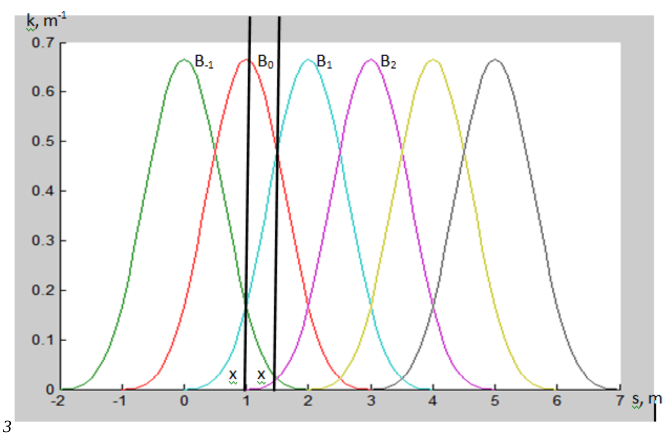

Fig. 1. Cubic base spline

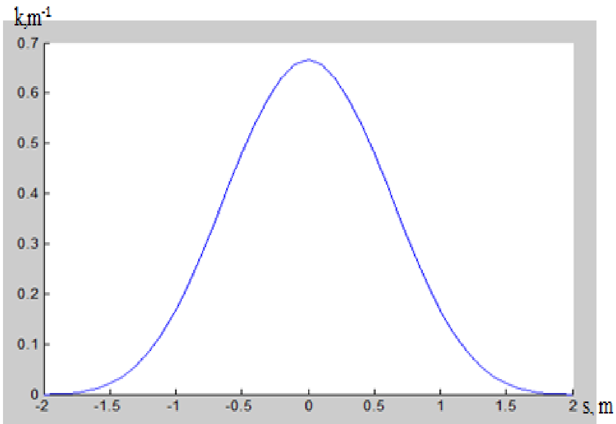

Fig. 2. Complex of cubic basic splines

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$S_m(x)$ of degree m with spline defect 1 which interpolates *f (x)* function can be represented only by using the sum of B-spline s:

$$f(x) \cong S_m(x) = \sum_{i=-1}^{m+1} b_i \cdot B_i(x), \quad a \le x \le b \ (2)$$

where b i - coefficients.
Thus, the study of methods for approximating functions and information obtained during the experiment (in the form of tables) using cubic splines showed the following:
1. The use of cubic basis splines for solving a number of problems, especially when approximating functions with resonant high-gradient points, gives better accuracy results relative to other polynomials.
2. When functions and information obtained in the course of an experiment are approximated (in the form of tables), the local property of B-splines is manifested using formula (2). This indicates that the value of this function at an arbitrary point can be represented only in the form m + 1 (here m is the degree of the spline), coefficients can be determined by a linear form as the sum of the products of basic elements. The above polynomial (2) is the basis for parallelizing computations and creating parallel architectures of specialized processors.
Recently, the theory of multidimensional splines of approximation functions with many variables has been developed. If we keep in mind only the area of interpolation polynomial splines, the definition of one-dimensional splines will expand to the state of many arguments. Moreover, the function S m (x, y) will be a two-dimensional spline of degree m with respect to the grid { x i , y i } . If it coincides with a polynomial of degree m, then x and y for each right angle D will be similar.
For each argument, multidimensional polynomial B -splines of equal degree m will be defined as the tensor product of one-dimensional B -splines:

$$B_m(x, y, \ldots\ldots \mu) = B_m(x) \otimes B_m(y) \otimes \ldots\ldots \otimes B_m(u)$$

In particular, for a two-dimensional spline S m (x, y) of degree m, the formula will be applicable:

$$S_m(x, y) = \sum\sum b_{ij} B_{m,i}(x) B_{m,j}(y),$$

AT given amount secondary brief works coefficients and one-dimensional B - Splines will be the denominator , the expression [x i , x i + 1 ; y j , y j + 1] for determining non-zero values of a two-dimensional basis spline

$$B(x, y) = B(x) \otimes B(y)$$

will be a rectangle , which is obtained by grinding the grid :

 x x0 <x1 <x2 <... <x n1-1 <x n1 ;

 y: y0 <y1 <y2 <... <y n2-1 <y n2 .

So Thus, local properties of one-dimensional splines are fully distributed for multidimensional splines. At the same step and approximation, a two-dimensional spline can be expressed by two one-dimensional splines.

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Table 1.Comparison of polynomial approximation functions

Comparison options	Lagrange polynomial	Newton's polynomial	Spline
Calculation error	$1.0\,8 * 10^{-8}$	$1.88 * 10^{-8}$	$0.2\,0 * 10^{-8}$
Methodical errors	$\varepsilon \le (3/128)\max\lvert f^4(x)\rvert h^4$	$\varepsilon \le (3/128)\max\lvert f^4(x)\rvert h^4$	$\varepsilon \le (4/384)\max\lvert f^4(x)\rvert h^4$
Number of calculations (for architecture with the core N = 1024 4)	7372	9420	4096
Interpolation	The system of equations is solved.	The system of equations is solved.	The system of equations is solved, but the matrix of equations is not complete, 3-5 diagonal. There is an effective method for solving them - the sweep method.
Approximation	With an increase in the number of nodal points, the degree of the polynomial increases, as a result of which the error value increases.	With an increase in the number of nodal points, the degree of the polynomial increases, as a result of which the error value increases.	You can use “point” formulas. The degree of the polynomial does not increase with an increase in the number of nodal points.

The analysis of existing methods of approaching the task of interpolating functions was considered, at the same time if in the beginning to understand the process by interpolating the values of the search functions for values of the argument, not represented in the table, but now refers to the concept of interpolation wider. In addition, this section addressed issuesapproximation interpolation nym Lagrange polynomial interpolation polynomialnymandNewton,spline function E, were identified advantages spline function minutes compared with other polynomials (seeTable).
Architecture of specialized processors for digital signal processing considered as the basic concepts of digital signal processing, traditional and multi-core architecture of digital signal processors, parallel algorithms designed for multi-channel architecture of digital signal processing.

Currently, the questions of analysis of many existing methods, algorithms and architectures used in digital signal processing, as well as the study of their advantages, remain relevant.
Digital signal processors (DSP) (born DSP - Digital Signal Processor) appeared much later than universal micro processes (MP). Their occurrence is associated with the specifics of digital signal processing (DSP) algorithms. In DSP algorithms, the most common operation is to calculate the sum of products, which is called the basic operation of DSP.
For the first time DSP appeared on the world market in the early 80's. In the following years, companies such as Texas Instruments (TI), Freescale (Motorola), Analog Devices (ADI) continuously developed DSP production for various industries. Today, DSP production technologies are developing dynamically.
To achieve the required speed, the following architectural solutions were implemented in the DSP:
Harvard architecture. In this architecture, the memory is divided into two areas: program memory (PP) and data memory (PD). At the same time, both command and information are read from memory .
Modified Harvard architecture. In this architecture there is the possibility of direct data exchange between PP and PD. This allows you to form teams in the form of an efficient pipeline .
Parallelization of commands on simultaneously operating functional modules.
The introduction of DSP, performed in one cycle, and the orientation of the basic operations on the device .
In 2005, Analog Device launched the production of ADSP BF 561 dual core DSPs.

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The development of microprocessor technology made it possible to switch from a multi-core and multi-processor architecture to a multi-core architecture, in which each core performs the functions of independent processors. This does not simplify the process of the production of programs for the preparation and writing of algorithms, but makes it possible not to increase the volume of unsolved problems, but to expand the area of parallel computing.
Consider the parallelization algorithm , the process of recovering data obtained during the experiment and using cubic basic splines, splitting into threads using Open MP . If the formula (2) given in the first chapter of the dissertation is applicable to the cubic basis function, then we obtain the following function:

$$f(x) \cong S_3(x) = b_{-1}B_{-1}(x) + b_0 B_0(x) + b_1 B_1(x) + b_2 B_2(x)$$

As a result of the analysis of the traditional and multi-core architecture of digital signal processors, parallel algorithms have been developed for the multi-core architecture of digital signal processing. In recent years there have been fundamental shifts in the development of microprocessors. These shifts are characterized by the transition from a single-core architecture to a multi-core architecture. In particular, architectures of special processors, Harvard, von Neumann, as well as the companies Black fin and ADSP, are widely used.If each of the four multiplication operations is divided into parallel threads, then the parallel algorithm can be represented as follows. This algorithm can be implemented using a quad-core architecture. When transferring streams in the first place are executed sequentially, then in parallel, then again sequentially. This can significantly reduce the computation time (Fig. 3).

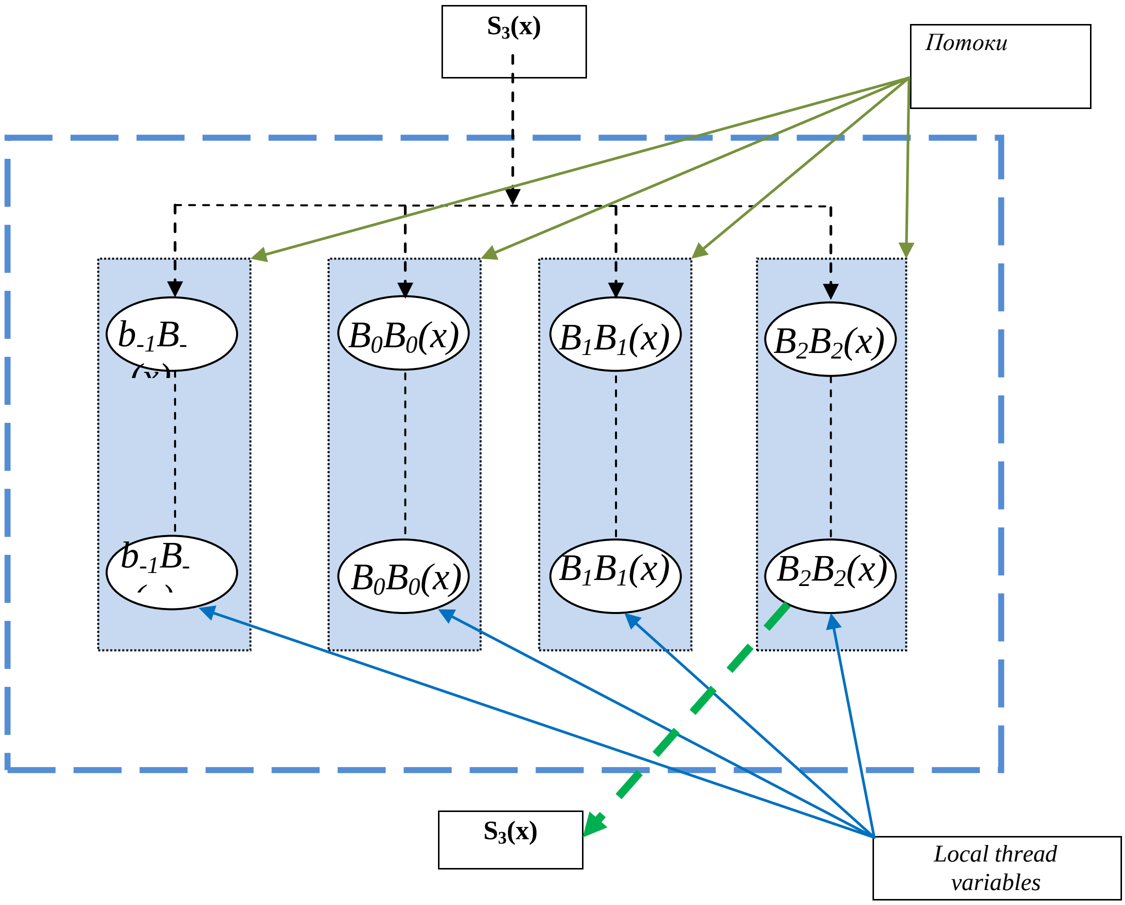

Fig.3. Flow Algorithm in Quad-Core Architecture

The process of transition to a multi-core architecture became possible as a result of lowering some technological standards, only increasing the tactical frequency of a single-core architecture that has physically exhausted itself. As a

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result of the use of multi-core processors, the parallelization of operations is possible, which reduces the time of digital signals and improves the overall performance.
Parallel algorithms for digital signal processing based on cubic and bucolic splines describe the architecture of traditional and multi-core special processors based on cubic splines, multi-core architectures based on bucolic splines used in the restoration of two-dimensional functional connections.
The task of constructing splines based on experimental data presented in analytic and tabular form is reduced to the calculation of the coefficients b i . In general cases, a Δ-spline mesh should be defined.
Local formulas retain the smoothness properties of the approximation. The values of the parameters do not depend on the index i and the inclusion of points that are significantly distant from the current point. He are symmetrical. However, they are used only for two interior points of the area.
When errors are detected in the experimental results, the construction of an interpolation spline loses its meaning. In such cases, in order to reduce errors, it becomes necessary to apply smoothing splines.
The smooth spline refers to a spline that is “smoother” than an interpolating spline and passes near the point of experimental values.Minimize the functionality:

$$J(f)=\int_a^b |S''(x)|^2 dx+\sum_{i=0}^{N} 1/R_i(f-S_i)^2 \quad (3)$$

Where R i > 0 is the specified value. The smaller the coefficient Ri, the closer the spline function is relative to the given value f i .
To minimize the functional (3), it is necessary to solve a matrix linear equation with five diagonals. Based on the constructed spline, the excess factors are re-calculated and a new spline is constructed based on the new R i . The iteration process should continue until the spline value matches the specified “corridor”. The disadvantage of this method is the elimination of the compression of the experimental results.
When using the least squares method for approximation, the node of functions is located more than the node of splines. However, the following functionality should be minimized:

$$I(f)=\sum^{N}(f_i-S_i)^2 ,$$

where Si is a spline function, fi is a given functional dependence .
Thus, the analysis of methods for calculating approximation coefficients based on splines showed that the problem of constructing spline functions based on experimental results reduces to the problem of calculating coefficients b. For systems operating in real time, the proposed formula of "point" calculation of coefficients. The expression of functions in the form of basic splines is convenient for implementation in devices, the structure of the computation of which involves the use of the table-algorithmic method.
Thus, the main advantage of the structure is high-performance for table-algorithmic methods. Since the sum of the B-spline calculations is equal to the sum in the one-dimensional region m+1.

III. CONCLUSION

As a result of the research «Improvingthe efficiency of digital signal processing based on spline functions" the following results were obtained:

1. As a result of the study of spline methods, a method has been created for approximating a larger number of elementary functions used in practice using basic splines. This method allows us to express the functional dependencies of the mathematical apparatus of basic splines as the sum of the values of the products of constant coefficients and basic functions.

2. As a result of combining the capabilities of the theory of basic splines and table-algorithmic methods, parallel architectures of specialized processors with high efficiency were created. This allows you to significantly parallelize the calculations.

3. The process of transition to a multi-core architecture emerged as a result of the physical exhaustion of possibilities and an increase in performance by reducing the clock frequency and some technological standards of single-core processors. The use of multi-core processors made it possible to parallelize the execution of operations, as a result of which it is possible to reduce the time of digital signal processing and improve the overall performance.

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REFERENCES

[1]. Vorobiev V.A. On the effectiveness of parallel computing / Autometry. - 2001. - № 1.- p. 50-58.
[2] ZavyalovYu.S., Kvasov B.I., Miroshnichenko I.L. Methods of spline functions. - M .: Science, 1980. 352.
[3]ZavyalovYu.S. Leus V.A., Skorospelov V.A. Splines in engineering geometry. - M .: Mashinostr., 1985. - 224 p.
[4] Kh. N. Zaynidinov, Z. Boltasheva Tabular-algorithmic computational structure based on multidimensional spline approximation methods. // Actual problems of modern science, Moscow, 2004, №2, p. 202-204.
[5] ZaynidinovKh.N., Khamdamov O.R., Mirzayev A.E. Spline - method of the analysis and processing of many-dimensional geophysical fields // The Second International Conference In Central Asia on Internet The Next Generation of Mobile, Wireless and Optical Communication Networks (ICI 2006). September 19-21, 2006, Tashkent, Uzbekistan. IEEE Catalog Number: 06EX1492C with: ISBN: 1-4244-0543-2
[6] ZaynidinovKh.N., Khamdamov O.R., Mirzayev A.E. Piecewise basic methods of processing of aggregate signals on the basis of many-dimensional basic splines // The Second International Conference In Central Asia on Internet The Next Generation of Mobile, Wireless and Optical Communication Networks (ICI 2006). September 19-21, 2006, Tashkent, Uzbekistan. IEEE Catalog Number: 06EX1492C with: ISBN: 1-4244-0543-2
[7] Mirzayev A.E. Simulation of functioning of computing structure on the basis of cubic basic splines// "International conference IT Promotion in ASIA 2008". 22-26 septemberTashkent, Uzbekistan. –P. 189-193.
[8] HakimjonZaynidinov, AvazMirzaev, Hsein-Ping Kew, Do-Un Jeong. Piecewise-polynomial Bases and Specialized Processor for Digital Signal Processing. IEEE Symposium on Industrial Electronics and Application
[9] (ICIEA 2009), October 4-6, 2009, Kuala Lampur, Malaysia, -P. 599-603.

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