Data analysis based on a recursive approach

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Abstract

A method of data analysis based on data representation in the form of return recursion and recursive structures generated by it is considered. Problems to be solved: description of the measurement data representation model in the form of a structure of recursive calculations; for recursive structures, the concept of a recursive processor is introduced; the possibility of recursive decomposition of functions is shown, which makes it possible to build more efficient schemes for data analysis; it is shown that recursive schemes can be described by well-known interpolation polynomials.

Keywords

Backward recursion, data analysis, recursive processor

1. Introduction

A significant part of the information obtained in practice contains data associated with time moments or intervals and, thus, can be considered as one-dimensional or multi-dimensional time series. Quite often, such data contain interference for the elimination of which can be used by various tools, examples of which are frequency and correlation methods.

However, in the case of analyzing the results of active experiments [2,3], the responses to typical influences are well described by systems of differential equations. In addition, as shown in previous works [7, 8], the response signal can contain several components that have completely different nature and internal laws.

2. Data analysis by the backward recursion

To study data that is a time series, it is proposed to use a recursive recursion scheme, which has the form

$$x_n = a_1 x_{n-1} + a_2 x_{n-2} + \dots + a_k x_{n-k} \tag{1}$$

Expression (1) can be considered as a difference equation, which has the general form $\sum_0^k b_i x_{n-i} = 0$; $\left(a_i = -\frac{b_i}{b_0}, i > 0\right)$. This equation corresponds to the solution [1] expressed in a primitive recursive form, where x_n is explicitly expressed through the values of the step number, that is, as a sum of quasipolynomials of n as (2).

$$x_n = \sum_{l=1}^{m} \lambda_l^n p_l(n) \tag{2}$$

where λ_l – roots of the characteristic equation: $\lambda^k + a_1\lambda^{k-1} + a_2\lambda^{k-2} + \dots + +a_k = 0$, a $p_l(n)$ – polynomial of degree less ν_l, where ν_l – root multiplicity λ_l.

The original expression (1) using (2) can be considered as a form of representation of recursive functions of a given form. This form has a number of features, for example, the expression

$$u_{n+k} = C_k^{k-1} u_{n+k-1} - C_k^{k-2} u_{n+k-2} + \dots + (-1)^{k-1} C_k^0 u_n \tag{3}$$

reproduce sequence $\{u_n^k\}$, that is, k-th powers of natural numbers, including those subjected to affine transformations.

Technical or algorithmic implementation (3) makes it possible to build one of the variants of bionic computation models, the general requirements for the elements of which are that it must: have pipelined memory storing the set { u_{n+k-1}, u_{n+k-2}, …, u_n }; have a feedback system with transmission coefficients corresponding to the coefficients of the return sequence $u_{n+k} = a_1 u_{n+k-1} + a_2 u_{n+k-2} + ... + a_k u_n$; the signals in the data processing device [10] move in a natural order, and the signals selected from the memory cells, multiplied by the corresponding coefficients, are summed up in the input cell of the converter (regeneration point); all operations are synchronized in such a way that the general calculation cycle of all {ui} included in the above expression takes a time cycle T (lag).

Such general requirements for bionic computing make it possible to construct a class of devices that automatically allow analysis and identification of patterns. These possibilities open up due to the fact that the computational structures corresponding to expressions (3), (4) have certain properties. For example, the coefficients {ak}, which can, in general, be functions of some parameters or even the recursion step number. In this case, the case of constant coefficients allows us to consider the ability of back-recursive schemes to distinguish patterns of behavior of levels of time series. Signs of successful assimilation of patterns are described in work [4]. It is obvious that the system that implements calculations by formula (3) satisfies the criteria for successful assimilation.

Thus, recursive models of bionic computations make it possible to reproduce the processes of generalization of noisy data, that is, their automatic structuring and inclusion in a complex of conditions that cause the generation of regular sequences. In addition, they make it possible to implement practical implementations of computational algorithms and devices [5, 6] with fairly wide capabilities for solving problems of analysis of dependencies, forecasting, modeling. In addition, the obtained relations make it possible to construct compact numerical schemes for studying dependencies in the form of differential equations.

3. Conclusion

Thus, a model was developed for representing the expected functional dependencies in the data in the form of backward recursion.

4. Acknowledgments

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5. References

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