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THEORY OF INFORMATIVE CALCULATIONS: NECESSITY OF CREATION AND PROBLEMS OF DEVELOPMENT

Foundation of theory of informative calculations is represented. This theory was created analogously to analytical mechanics. Applications this theory for the problems of matrix calculations and for the formation of arrays are analyzed. Role of theory of informative calculations for the creation of polymetric analysis is shown too.

Keywords: informative calculations, de Broglie formula, polymetric analysis, informative lattices, formation of arrays.

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ТЕОРІЯ ІНФОРМАЦІЙНИХ ОБЧИСЛЕНЬ: НЕОБХІДНІСТЬ СТВОРЕННЯ ТА ПРОБЛЕМИ РОЗВИТКУ

Розглянуті основи теорії інформаційних обчислень. Показано, що цю теорію можна будувати по аналогії з аналітичною механікою. Проаналізовано застосування цієї теорії для задач матричного числення та сортування масивів. Також показано роль теорії інформаційних обчислень при створенні поліметричного аналізу.

Ключові слова: інформаційні обчислення, співвідношення де Бройля, поліметричний аналіз, інформаційні решітки, сортування масивів.

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ТЕОРИЯ ИНФОРМАЦИОННЫХ ВЫЧИСЛЕНИЙ: НЕОБХОДИМОСТЬ СОЗДАНИЯ И ПРОБЛЕМЫ РАЗВИТИЯ

Рассмотрены основы теории информационных вычислений. Показано, что эту теорию можно создавать по аналогии с аналитической механикой. Проанализированы применения этой теории для задач матричного исчисления и сортировки массивов. Также показана роль теории информационных вычислений при создании полиметрического анализа.

Ключевые слова: информационные вычисления, соотношение де Бройля, полиметрический анализ, информационные решетки, сортировка массивов.

Introduction

Problem of creation optimal theory of calculations or informative calculations is caused of the development of modern science, including physics, cybernetics and computer science [1-10]. Complexity of calculations is one of central problems of modern cybernetics and computer science [1-7]. This problem is included in famous important unresolved problems of modern mathematics (Smale problems) [1, 8, 9].

One variant of the resolution of this problem is theory of informative calculations [1, 2]. This theory may be represented as variant of the creation of universal system of calculations. The ways of resolution of this problem were searched by Pythagor and Leubniz [1]. Pythagorean way was founded on the synthesis of esoteric Egyptian system and “open” Sumerian system. Leubnician way was caused to creation of modern differential and integral calculations and mathematical logics [1, 9].

Another way resolution of this problem is theory of informative calculations [1]. This theory is based on the polymetric theory (theory of variable measure or theory of measure and measurements with including procedure of measurements in measure) of measure and measurements and is one of basic element of polymetric analysis.

Basic concept

Basic elements of this theory is the generalizing mathematical elements or its various presentations – informative knots [1, 3-7]. Generalizing mathematical element is the composition of functional numbers (generalizing quadratic forms, including complex numbers and functions) and generalizing mathematical transformations, which are acted on these functional numbers in whole or here elements [1, 3]. Roughly speaking these elements are elements of functional matrixes.

Generalizing mathematical elements are the elements of variable polymetric measure, which are included the procedure of measurements [1, 3]. This element ${}^{stqo}_{nmab}M_{ijkp}$ may be represented in next form

$$ {}^{stqo}_{nmab}M_{ijkp} = A_i\overline{A}_j O_k \overline{O}_p A^r_s \overline{A}^r_t O^r_q \overline{O}^r_o A^l_n \overline{A}^l_m O^l_a \overline{O}^l_b N_{\varphi_{ij}} \; . \tag{1} $$

Where $N_{\varphi_{ij}}$ – functional number; $A_i, A^r_s, A^l_n, \overline{A}_j, \overline{A}^r_t, \overline{A}^l_m$ are qualitative transformations, straight and inverse (with tilde), (r) – right and (l) – left.

Functional number $N_{\varphi_{ij}}$ may be represented as [1, 3]

$$ N_{\varphi_{ij}} = \varphi_i \circ \overline{\varphi}_j \; , \tag{1a} $$

where $\varphi_i = \varphi_i(x_1,...,x_n,\overline{x}_1,...,\overline{x}_n)$ and $\overline{\varphi}_j = \overline{\varphi}_j(x_1,...,x_n,\overline{x}_1,...,\overline{x}_n)$ – straight and inverse (with tilde) functions; $x_i, \overline{x}_j \; i, j \in (1,n)$ – straight and inverse (with tilde) parameters.

Generalizing mathematical element may be represented universal measure of quantity of information [].

These elements are created informative lattice [1, 3]. For this case it was called as knots []. Informative lattice is basic array of theory of informative calculations. This theory was constructed analogously to the analytical mechanics [1, 10].

Basic elements of this theory are:

1. Informative computability *C* is number of possible mathematical operations, which are required for the resolution of proper problem.

2. Technical informative computability $C_t = C\sum t_i$, where t_i – realization time of proper computation.

3. Generalizing technical informative computability $C_{t0} = k_{ac}C_t$, where k_{ac} – a coefficient of algorithmic complexity [1].

Basic principle of this theory is the principle of optimal informative calculations [1]: any algebraic, including constructive, informative problem has optimal resolution for minimum informative computability *C*, technical informative computability C_t or generalizing technical informative computability C_{to}.

The principle of optimal informative calculations is analogous to action and entropy (second law of thermodynamics) principles in physics.

This principle is more general as Shennon theorem [1, 3-7, 10-14].

Idea of this principle may be explained on the basis de Broglie formula [15]

$$ S_a/\hbar = S_e/k_B \tag{2} $$

(equivalence of quantity of ordered and disorder information) [1,5]. Where S_a – action, $\hbar$ – Planck constant, S_e – entropy and k_B – Boltzman constant. Therefore we can go from dimensional quantities (action and entropy) to undimensional quantity – number of proper mathematical operations.

Basic applications

This theory was used for the estimation of effectiveness of matrix calculations and problem of formation of arrays [1].

For the practical application we must include normalized measure of calculations $\text{mes}\, N\left\{ {}^{stqo}_{nmab}M_{ijkp} \right\}$

$$ \text{mes}\, N\left\{ {}^{stqo}_{nmab}M_{ijkp} \right\} = \frac{\text{mes}\left(N\, {}^{stqo}_{nmab}M_{ijkp}\right)}{\max\left\{\text{mes}\left(N\, {}^{stqo}_{nmab}M_{ijkp}\right)\right\}}. \tag{3} $$

Norm of functional matrix and normalized measure of calculation are comfortable characteristics for practical estimations of proper calculations (transformations).

Now we are representing the example of application this theory to matrix calculation [1,16]. Matrix calculations(computations) are basic for computer processors [1, 3, 17]. For this case we are using the principle of optimal informative calculations.

For squarte matrix

$$ C = \overline{C}; \;\; C_t = \overline{C}_t; \;\; C_{to} = \overline{C}_{to}, \tag{4} $$

where $C, C_t, C_{to}, \overline{C}, \overline{C}_t, \overline{C}_{to}$ – proper informative calculations for straight and opposite (with tilde) matrix multiplication.

For multiplication of rectangular matrixes

$$C \neq \overline{C};\ \ C_t \neq \overline{C}_t;\ \ C_{to} \neq \overline{C}_{to}. \tag{5}$$

Computing procedures with conditions (4) were called symmetrical, with conditions (5) – asymmetrical,

Now we represent the examples *C* for the multiplication of various types of matrixes. Further we marked *C* as Π – number of algebraic operations only.

1. Multiplication of two matrixes with dimensions $m \times n$.

In one case (”straight” multiplication) we have square matrix with dimension $m \times m$, and in second case (inverse multiplication) – $n \times n$. Number of operations for proper multiplication is equaled:

for $m \times m$ matrix

$$\Pi_m = m^2(2n-1); \tag{6}$$

and for $n \times n$ matrix

$$\Pi_n = n^2(2m-1). \tag{7}$$

2. Let matrixes with dimension $m \times n$ are reduced to quasidiagonal type and $m/p = n/t = k$. Then its number of operations is equaled

$$\Pi_{ptk} = p^2(2p-1)+k; \tag{8}$$

$$\Pi_{tpk} = t^2(2t-1)+k. \tag{9}$$

3. Multiplication of square matrixes:

а) general case –

$$\Pi_n = n^2(2n-1); \tag{10}$$

б) diagonal case –

$$\Pi_n = n; \tag{11}$$

в) quasidiagonal cases –

1) $n/p = n/t = k \quad (p = t)$;

$$\Pi_{k_1} = t^2(2t-1)+k\ ; \tag{12}$$

2) $n/p = k;\ n/t = l;\ k \neq l$;

$$\Pi_{nkl} = p^2(2p-1)+k\ ; \tag{13}$$

$$\Pi_{nlk} = l^2(2l-1)+k\ ; \tag{14}$$

Proper estimations were received for functional and block matrixes [1, 16].

Criteria of estimations of effectivity of calculations may be proofed from formula (3). For matrix calculation it may be represented in next form [1]:

analog of normalized measure of calculations

$$\Delta_i = \frac{\Pi_i}{\Pi_{\max}} \tag{15}$$

and inverse to Δ_i quantity

$$\delta_i = \frac{1}{\Delta_i} = \frac{\Pi_{max}}{\Pi_i}. \quad (16)$$

The proper estimations of quantity δ_i were received for various types of matrix calculations. For each type of matrix multiplication we must select proper Π_{max}.

For example for square and other matrixes multiplications δ_i may be have various functional forms [1].

Calculative gain δ_i for some types of matrixes multiplications may be $>10^3$.

This concept was used for the estimations of effectivity of formation arrays too [1].

In addition theory of informative calculations has fundamental value: it is one of basic element of polymetric analysis – universal system of analysis, synthesis and formalization of knowledge [1,5,18,19].

All possible systems of knowledge may be classified with help hybrid theory of systems (system theory of polymetric analysis) was created. This theory is based on two criterions: criterion of reciprocity – principle of creation of proper formal system, and criterion of simplicity – principle of optimality of this creation. For "inner" bond of two elements of informative lattice a parameter of connectedness was introduced. Principle of optimal informative calculation is included in criterion of simplicity. Only 10 minimal types of hybrid systems are existed. But four types of these systems aren't mathematical in classical sense [1]. Hybrid theory of systems is open theory. Parameters of openness of this theory are number of generalizing mathematical transformations and parameter of connectedness. Thereby we have finite number of types of systems, but number of systems may be infinite. Hybrid theory of systems allows considering verbal and nonverbal knowledge with one point of view [1, 4-6]. Roughly speaking this theory may be represented as variant of resolution S. Beer centurial problem in cybernetics [1,20].

Mathematical constructive element may be represented as generalizing knot of informative lattice. Generalizing mathematical transformations are classified as quantitative and qualitative, left and right. Calculative (quantitative) transformations are corresponded to primary measurement and qualitative transformations – to derived measurements. It allows formalizing N.R. Campbell concept [21] about primary and derived measurements. Result of this formalization was named polymetric theory of measure and measurement. Basic principles of this theory are principle of asymmetry of measurement for calculative transformations and principle of dimensional homogeneity. This theory is optimal synthesis of all famous theories of measure and measurements and dimensional analysis [1]. Basic element of this theory is generalizing mathematical element – functional expansion of number-measure. N.R. Campbell concept is more general as "measuring" part of quantum mechanics. Therefore L.I. Mandelstam called Quantum Mechanics as science of derivative measurements [22].

Polymetric analysis is the system of optimal formalization, synthesis and analysis of knowledge. But it is the nature of mathematics [1, 9]. For creation of theory of foundations of mathematics we must include three aspects: synthesis, analysis and formalization. This theory must be open system. Therefore Russel – Whitehead "logic" concept, Hilbert – Bernayce"formal" concept and Brauer – Heiting "constructive" concept can't be full theories of foundations of mathematics [1, 9]. It was cause of crisis in theory of foundations of mathematics. Therefore A.N. Whitehead made conclusion that logical concept can't be the theory of foundations of mathematics [12]. But it must be "organism" theory. Practically this concept was realized in cybernetics: theory of neuronets, systolic computers, theory of cellular automata a.o. [1]. With point view of neuronets theory polymetric analysis is more general theory, where neurobonds may be represented with help of generalizing mathematical transformations and parameter of connectedness. Therefore polymetric analysis may be represented as variant of realization of Whitehead concept of "organism" mathematics [22] and formalizing unification of proper cybernetic theories [1].

Roughly speaking it is the optimal system synthesis of logistic, formal and intuitive directions of foundations of mathematics.

Polymetric analysis may be represented as variant of resolution of problem of century in cybernetics (problem of complexity) according by S.Beer [20]. This problem is connected with problem of calculations according to [1, 8]. Problem of complexity of computation (calculation) is one of central problem of computing science and and is one of unresolved problems of XXI century [7, 17].

Polymetric analysis may be represented as optimal "dynamical' formalization of Errol E. Harris polyphasic concept of modern science [1, 24].

Methods of polymetric analysis were used for the decoding of possible Pythagorean civilization of VI – V B.C., which was open by German archeologists in Mediterranean in 1980 – 1984; and for decoding of mathematical and linguistically part of Table of God Thot (Egyptian mythology) [1]. Multiplicative (operative) mathematical system was used for these cases. Zero and infinity weren't important elements of these systems [1]. Practically it is optimal functional expanded Pythagorean system (numbers is ruled the World) with modern point of view.

Functional numbers and generalizing mathematical elements are the numbers of third generation (number is the system element). Therefore polymetric analysis may be represented as theoretical foundations of modern computing (informatics). Basis thesis of this science according to A. Yershov is words of Canadian philosopher "All that go from head is intelligent" [1]. Therefore theory of informative calculations may be used in all applications of computing.

Conclusions

Thus we can make next conclusions:

1. The necessity of creation the theory of informative calculations is represented.
2. Basic concept of this theory is analyzed.
3. Application this theory for the problems of matrix calculations and formation of arrays is observed.
4. Place and role of theory of informative calculations for the creation of polymetric analysis is analyzed too.

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