METHODS OF SYNTHESIZING REVERSIBLE SPATIAL MULTIVALUED STRUCTURES OF LANGUAGE SYSTEMS

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Abstract: The basic construction concepts of multivalued intellectual systems (MIS), which are adequate to primal problems of person activity and using hybrid tools with many-valued coding are considered. The concepts are agreed with the dialectic laws opened by a man and their manifestations in problems connected with creation of identification systems prediction and recognition of imagery in which the interactive operational mode is a main part of the whole complex of intellectual properties. The law of unity and struggle of contrasts changes and alternation of coding indications of messages about objects in neurons of a brain - from space to temporal and from two-place to multivalued.

Keywords: multivalued intellectual system, language systems, parallelism (spatial), AFP (algebra of finite predicates), AFP-structures, knowledge base, multiplevalued logic, multistate reversible element.

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Introduction

Developing and improving computer facilities underline the process of automatizing mental activity, which was the starting - point of emergence of concept of artificial intelligence. However, the successes in the field of intellectualizing computer machines are insignificant especially if one compares the achieved results with anticipated ones and forecast. The orientation on the attain of qualitatively new technologies of information processing manifest itself in attempts to realize systems of artificial intelligence (AI) on Neumann computers. Therefore, new requirement of the technology of information processing are caused by need for solving problems which are badly formalized and the availability of user who is not a professional programmer. (1) Thus, we came to realizing one of the variants of developing AI systems - this is the way of analyzing modeling and synthesizing a natural language intelligent interface by means multiple-valued logical systems, in particular by the algebra finite predicates as well as the theory of multiple-valued structures and coding. Since the advent of computers facilities research has been carried out and realization at the level of engineering solutions multi-valued structures and coding in view of high information saturation of their signals has been conducted. Structures of data processing means, which are conducted on the basis of multiple-valued logical elements and modules with appropriate links, are called multiple-valued ones. All the objects, which are described by finite structural alphabet: elements, modules, structures, system of computer, measuring and control facilities and natural language information tools are classified among such structures.

At present there exist a great number of uncoordinated approaches and methods of building and applying multiple-valued structures, however, their systematization and classification are not available (i.e. any kind of an ordered system of realization means). At the same time the optimum design and technical realization of computer machines on the base of multi-valued structures are impossible without simultaneous development of entirely new (nontradional) kinds of mathematical models and their research for various models of operation and interpretation of the modeling results. All this has resulted in a critical situation, which is caused by the absence of the integral theory of constructed highly effective multi-valued structures of spatial type. The analysis done shows

that the problem of developing the generalized theory of building highly effective multiple-valued computer structures and coding for language systems can be solved only within the class of intuitive and constructivist theories [1-4].

In particular, in works the accent on the concept of neuro -physiologic and neuro - cybernetic aspects of alive brain mechanisms is made. It is connected with the following natural neuron structures from nervous cells - neurons, essentially are highly effective recognizing systems and, for this reason, is of interest not only for doctors and physiologists, but also for the experts designing artificial intelligence systems. However direct transfer of research results of neuro- physiologists in engineering practice is now impossible because of a lack of an appropriate bioelectronic technology and an element basis, that has led to development and creation of a set of varieties of artificial neurons realized on the elements of the impulse technology.

As the corollary, non-adequacy of used principles of coding and element basis to simulated processes entails a redundancy, complication and non evidence of used mathematical and engineering means of transformations, loss of a micro level of parallelism in handling expected fast acting and flexibility of restructuring without essential modifications of architecture and connections.

1. Choosing the Body of Mathematics

The availability of algebra of finite predicates (AFP) provides an interesting opportunity of realizing a transition from algebraic description of information processes to their description in the form of equation in the language of given algebra and the equations specify relations between its variables [5,6]. All the variables in the equation possess equal rights and any of them can be both independent and dependent ones. The presence of equations and their advantage over algorithms consist in the fact that there appears an opportunity to calculate the reaction of the system even in case of the incomplete definiteness of initial information, whereas an incompletely developed algorithm is unable to operate. One should note that by means of AFP-structures which realize appropriate finite predicates. The given approach is similar to the process of constructing combinational circuits by the formula of the algebra of logic. Depending on the level of functional and structural realization we have AFP-structures of the first, second and third level 6].

The algebra of finite predicates is used as the body of mathematics of the research. We treat AFP as the one which is represented by the set M of all the predicates U^m. Let T be a set of all relations on U^m, Q be a set of all predicates on U^m. The relation T and predicate Q are called corresponding to each other, if for any $x_1, x_2, \ldots, x_m$ we have:

$$Q(x_1, x_2, \ldots, x_m) = \begin{cases} 0, if \ x_1, x_2, \ldots, x_m \notin T; \\ 1, if \ x_1, x_2, \ldots, x_m \in T. \end{cases} \tag{1}$$

In accord with (1) there can be a transition from the arbitrary relation T to predicate Q corresponding to the said relation T. The predicate Q which is found by the expression is called the characteristic function of relation T. The condition of the form:

$$a(x_i) = x_i{}^a = \begin{cases} 0, if \ a \neq x_i; \\ 1, if \ a = x_i. \end{cases} \tag{2}$$

is called predicate of recognizing an object $a \in U$ of variable $x_i, i = \overline{(l, m)}$.

The predicate $a(x_i)$ should be considered as the predicate $a(x_1, x_2, \ldots, x_i, \ldots, x_m)$ from $P \subseteq Q$, whose all arguments, except x_i, are negligible. We will replace the expression in the form $a(x_i)$, where $i = \overline{l, m}$, $a \in U$

by x_i^a (here a is called an exponent of the variable x_i. Thus, the set T and basic elements x_i^a ($i = \overline{l, m}$, $a \in U$) and basic operations: disjunction, conjunction and negation is called the algebra of finite predicates over M. Eliminating the operation of negation out of the basis of the given algebra enables to obtain the so called disjunction and conjunction algebra of predicates (DCAP). Its completeness is proven [5]. Thus, the given algebra is considered as an instrument of research but not as its subject.

2. Formalizing the Concept of Unification of Spatial Multiple-valued Structures

A concept of unifying (reducing to uniformity and indissoluble interaction) two-digit and multi-valued means of processing appropriate (symbolic) data semi digital in a natural language. The present approach is based upon a single methodological and special purpose principle by applying the proposed methods of the theory of intelligence [7] for mathematical description and appropriate formalization of the concept of unifying input/output data [8] and their intermediate transformation [9] an appropriate AFP-structure of the third sort (Fig.1) [5].
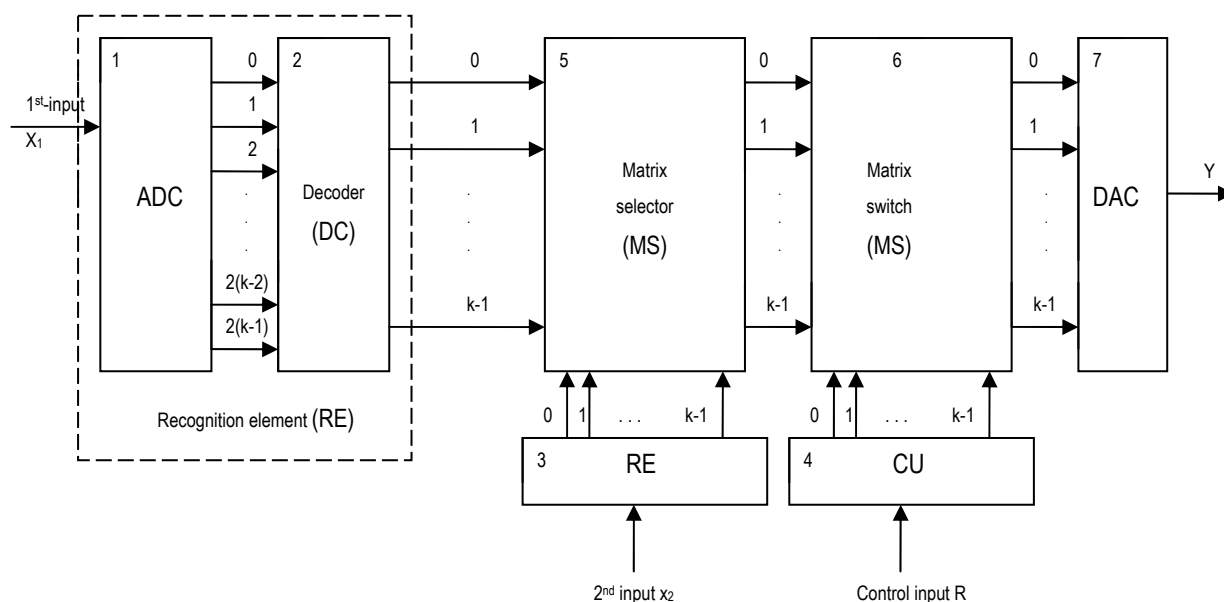

Fig.1. Two-input AFP-structure of the third sort

AFP-structure of the third sort is proposed on the basis of the sdf architectural studies presented in the works [5-8], as well as proceeding from the need for structurizing problems in developing the intuitive and constructivistical theory of constructing multiple-valued structures of spatial type for language systems.

AFP-structure of the third sort based upon a two-input universal multivalued functional converter [5] includes the following components: a recognition element (RE) n-valued variable which is formed by a parallel ADC together with a spatial DC, a MS and MSW, a control unit, a parallel digital-to-analogue converter (key switch). After describing the logic of operation of these components by the appropriate equations of the algebra of finite predicates, we will obtain their mathematical models. The use of the concept of unification and the given algebra will ensure boundary parallelism and uniformity of the structure as a whole. Obtaining analytical relations of input /output variables of component will make it possible to formalize and automatize synthesis procedure of multiple-valued structures of spatial type [5,6].

An RE of k-valued variable realizes the recognition predicate - the basic element of the algebra of finite predicates. The AFP is specified on the set M of all n-place k-valued predicates, i.e. the function of the form

$y = f(x_1, x_2, \ldots, x_n)$, where $x_1, x_2, \ldots, x_n$ are letter variables specified on alphabet of letters $A = \{a_1, a_2, \ldots, a_n\}$, $y \in \{0,1\}$ is a logic variable, i.e.

$$x_i^{a_j} = \begin{cases} 0, & \text{if } a_j \neq x_i; \\ 1, & \text{if } a_j = x_i, (i = \overline{1,n}, \ j = \overline{1,k}). \end{cases}$$

As the recognition element has k-levels ($0 \div (k-1)$), the number of output recognition signals for a spatial set of the RE will constitute: $k : a_1, a_2, \ldots, a_{k-1}$. Thus, paralleling the process at the level of the boundary speed of response of appropriate transformation is provided already at the AFP-structure input. The logic of operation of DC particularly decoder 2 (DC 2) is described by a set of the AFP equation of the following form:

$$\begin{cases} b_{1,2,3}^0 = \overline{y_1}; \\ b_{1,2,3}^1 = y_1 y_2; \\ \ldots \quad \ldots \quad \ldots \quad \ldots \\ b_{1,2,3}^{k-1} = y_{k-1}; \end{cases}$$

The logic of operation of MS 3 is described by a system of the AFP equations of the following form:

$$\begin{cases} g_{00} = b_1^0 \& b_2^0; \ g_{01} = b_1^0 \& b_2^1; \ g_{0(k-1)} = b_1^0 \& b_2^{k-1}; \\ g_{10} = b_1^1 \& b_2^0; \ g_{11} = b_1^1 \& b_2^1; \ g_{1(k-1)} = b_1^1 \& b_2^{k-1}; \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ g_{(k-1)0} = b_1^{(k-1)} \& b_2^0; \ g_{(k-1)1} = b_1^{(k-1)} \& b_2^1; \ g_{(k-1)(k-1)} = b_1^{(k-1)} \& b_2^{k-1}. \end{cases}$$

where g_{ij} is the output signals of matrix selector, which take the values out of the set $E_2 \in \{0,1\}$, $i, j \in \{0, 1, \ldots, k-1\}$. The logic of operation of the space switch in the AFP-structure of the first sort is described by the following system of the AFP equation:

$$\begin{cases} g_{00}^0 \vee g_{01}^1 \vee \ldots \vee g_{0(k-1)}^{(k-1)} = q_0, \\ g_{10}^0 \vee g_{11}^1 \vee \ldots \vee g_{1(k-1)}^{(k-1)} = q_1, \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ g_{(k-1)0}^0 \vee g_{(k-1)1}^1 \vee \ldots \vee g_{(k-1)(k-1)}^{(k-1)} = q_{(k-1)}. \end{cases}$$

Correspondingly, the switch input signals are formed at the expense of the wire OR for signals with the same indexes but with different commutation level:

$$\begin{cases} z_0 = r_0 \vee s_0 \vee q_0, \\ z_1 = r_1 \vee s_1 \vee q_1, \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ z_{(k-1)} = r_{(k-1)} \vee s_{(k-1)} \vee q_{(k-1)}. \end{cases}$$

The final result of the universal conversion can be formally represented in the form of the following operator picture:

$$F(z_i) = \max_{i=0}^{k-1} \left(\min_{i=0}^{k-1} z_i t_i \right),$$

where $i = \overline{1, k-1}, (t_0, t_1, \ldots, t_{k-1})$ are sets of signals of adjusting (selecting) the output functions of the universal AFP-structure of the third sort. Thus, the aim of this approach is achieved by decompiling multiple-valued

hardware means (AFP-structures of the third sort) into multiple-valued and two-value discrete and analogous subunits, especially in the part of their intermediate spatial information transformation.

The research has shown that the application of traditional methods of combinational synthesis in functionally complete bases as disjunction (conjunction) normal forms to multiple-valued structures of spatial type is ineffective from the point of view of retaining the properties of uniformity and parallelism of structural formations [3,5]. There is a need for seeking objects of research which are the most natural and closest to the inner logic of functioning for a natural language particulary of corresponding structures a variety of algebraic and logical means of modeling and new methods of synthesis of corresponding structures [5,9].

In problem of information processing in a natural language (for instance, in a Slavonic one) one needs to recognize and process not less than 33 letters already at the level of phonetics. Consequently, beginning already with problems of phonetical level of language information processing, value increase is an inevitable problem of further research. It is evident that considering such an approach to the investigation of problems of creating and constructing AFP-structures of the third sort on the base of universal multiple-valued functional converters requires expanding from the point of view of increasing the values of a structural alphabet ($k > 3$)

As the converter has a property of universality, the power of a set of functions which can be realized by a one-input AFP-structure of the third sort makes up the value $N = k^k$. Increase the digits of the structural alphabet (the number of analogue-to-digital converter parallel stages out of comparator series).
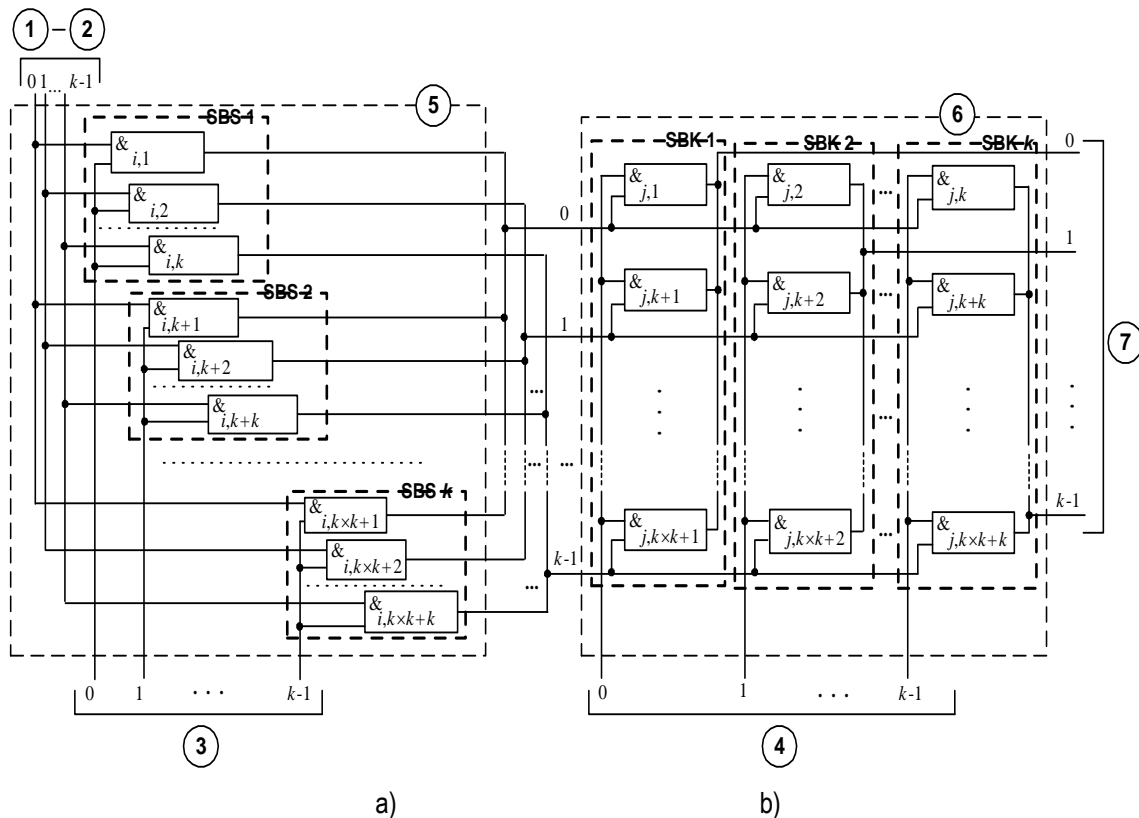

Fig.2. Structure and logic of realization of combinationed of matrix circuits of: a) a selector b) a switch

With a joint reference voltage divider from 3 to 10 makes it possible to increase the functional potentialities with respect to realizing a set of logical functions of one variable to 1010/33 times. Thus, applying two-input AFP-structure, of the third sort, as well as constructing a space decoder, a matrix selector and switch on conjunction elements enable to ensure uniformity and homogeneity of its inner structure, as well as to increase speed of

response at the expense of the boundary parallelism of the structure. The AFP-structure uses logical, but not computing methods of intermediate transformation with the use of the concept of unifying 2 digit and k-valued coding, which ensures the simplification of structure of intermediate subunits of a matrix selector and a switch (Fig.2)

3. Solution Process of the Task of Hypothetically Connected Subscribers

This part of article is devoted to building of formalization methods of the relation with linear logical transformation. It is a main tools for realization of logic network which focused on parallel information processing and its program realization.

Let variables x_i, $i = 1, 2, ..., 12, ...$ - are the telephone numbers of city Kharkiv and Kharkiv area. The task consists of finding all telephone numbers of subscribers, with which can be connected subscribers numbers x_1, x_2, x_4, x_7, x_9. The numbers set of subscribers, on which entrance rings are fixed will designate y_j.
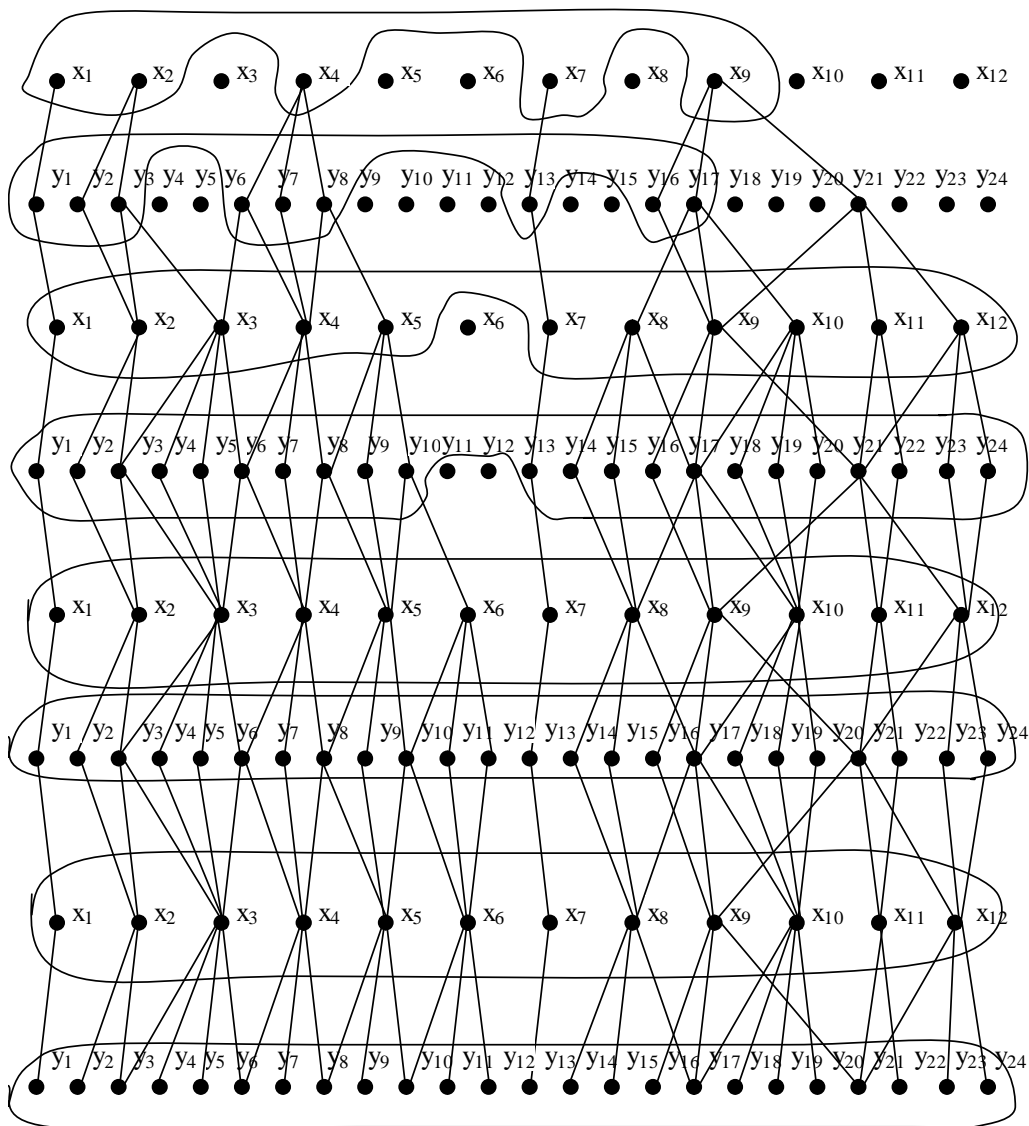

Fig.3. Finding of the hypothetically connected subscribers

On Fig.3 evidently, that subscribers, x_1, x_2, x_4, x_7, x_9 hypothetically connected with subscribers $y_1 - y_{24}$, a decision is found for 3 steps. The using the developed method of finding the degree of linear logical transformation allow to minimize time to search decisions of this task.

Variable x_i, $i = 1,2,...,12,...$ - are the telephone numbers of Kharkiv and Kharkiv area. It is necessary to find the telephone numbers of subscribers, with which can be connected subscribers with numbers $x_1 = 0572230508$, $x_2 = 0572945376$, $x_4 = 0577124387$, $x_7 = 0577774004$, $x_9 = 0577711691$. The numbers set of subscribers, where rings acted is presented in [10].

Thus, the followings numbers of subscribers Kharkiv and Kharkiv area were found:

$x_3 = 0577153256$, $\quad x_5 = 0577356578$, $\quad x_6 = 0572995633$, $\quad x_8 = 0577332376$, $\quad x_{10} = 0572278745$, $x_{11} = 0577126534$, $x_{12} = 0572937694$.

Conclusion

Thus, the above listed results make it possible to make the following important conclusion: using new algebraic and logical means of modeling of natural language constructions in the form of a system of equations based on the AFP-language and explicit way of specifying a finite alphabet operator which underlies method of solving these equations, ensures realization the property of reversibility of AFP-structures and a wide paralleling of symbolical information processing. Fundamental research of the algebraic and logical structure of an natural language as well as algebraic and logical means of its modeling in the form of AFP-structures of the first, second and the third sort permits to come close to the solution of the important scientific problem: attaing qualitatively new technologies of symbolical information processing on the basis of the concept of unification and methods of synthesizing reversible spatial multivalued structures of language systems. The way of method of n-th power of linear logical transformation's adaptation in complex accounts computer-based system of integrated data-processing system of telecommunications enterprise is adduced.

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