About Digital Information Processing on the Base of Polistoral Logic

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Nowdays it is very important to have fast data processing capabilities for experimental equipment and not only. Examples of problems which can not be solved in limited time are problems of so called NP class (Carp, Shore, Karateodori). They are principally unsolvable using classic logic. In the work [1] a method for relative mechanical displacements measurement is purposed. The method is based on the idea to concentrate information in the carring physical signal. This allows to find out not only the "center of gravity's" trajectory of the optical beam, but also distribution of intensity in the cross section of the beam. Concentrated information processing is not a trivial problem. One of the ways to solve this problem is in the use of multivalue logic.

There are 3 ways of development of the problem of information processing eficiency increasing. One of the ways is purposed by Feinman [2] and referes to organizing quanto- correlated controll of a system of computers, i.e. use of logic in control, which is quato- correlated product of several bulean logics:

$$\mathcal{L}_F = \otimes_1^n \mathcal{L}_B \tag{1}$$

where $\otimes$ - means quatium correlated product, n - number of parallel computers represents the level of information concentration in controlling signal.

The second way purposed by Neumann and Birkhoff [3] referes to use of quantum logic in information processing. This is extended (furtermore maximal) method. $\mathcal{L}_q$ quantum logic includes $\mathcal{L}_B$ and $\mathcal{L}_F$, non distributive, multivalue and with an uncertain element, and bears maximal information (like analog signal).

Both of the ways are high effective, but there are some difficulties connected with their realization. In particular, Feinman's computers require very low temperatures ($10^{-7}k$), high isolation and, etc. For Neumann's version there is no suitable element yet.

The third way, offered by H. Karayn [4] seems to be more realistic. It is connected with use of multistable physical systems which have at last one macroscopic parameter. Advantage of this method is that the realization element can be created on the base of polistoral semiconductor structures. They posses multivalue and undeterministic properties if necessary. Information exchange is realized by collective effect of plazma - field interection, which is the base for controll of a system of polistors.

We, together with H.Karayan, purpose new polystoral logic system $\mathcal{L}_p$ [5], which is a physical system. The difference of $\mathcal{L}_p$ is that there is no logic function or operation in its axiomatic. It uses logic hidden in the system only. As the hidden logic may be very complicated the use of $\mathcal{L}_B$ Bulean logic system may be impossible. Then the physical logic system becomes preferable to the classic system.

Here $\mathcal{L}_p$ axiomatics is given. It is the minimal multivalue logic system and it is possible to extend up to $\mathcal{L}_q$.

Beside traditional symbols following brackets are also included in $\mathcal{L}_p$ alphabet: $\langle a,\ b,\ \ldots,\ c\rangle$ - conjunction brackets mean that events $a,\ b,\ \ldots,\ c$ takes place simoultaneusly, $\begin{bmatrix} a \\ b \\ \vdots \\ c \end{bmatrix}$ - disjunction brackets mean that only one from events $a,\ b,\ \ldots,\ c$ takes place depending on given conditions. In the alphabet of $\mathcal{L}_p$ logic a set $\mathcal{A}_p = \{0,\ 1,\ \ldots,\ E\}$ is also included. It is a set of equidistant discret magnitudes (coinciding with parameters of multistable system with precision of an index).

The following is the set of operators $\mathcal{O}_p$

$$
\begin{array}{lll}
1.\ \forall x \in \{0,\ 1\}, & & x + \bar{x} = 1 \\[2ex]
2.\ \forall x \in \mathcal{A}_p, & & x + Ix = E \\[2ex]
3.\ \forall x \in \mathcal{A}_p, & & h\langle x_i,\ \ldots,\ x_n\rangle = \begin{bmatrix} E \\ 0 \end{bmatrix} \\[2ex]
4.\ \forall x \in \mathcal{A}_p, & & S\langle x_i,\ \ldots,\ x_n\rangle = \begin{bmatrix} 1 \\ 0 \end{bmatrix} \\[2ex]
5.\ \forall x \in \mathcal{A}_p, & & k\langle x_i,\ \ldots,\ x_n\rangle = \begin{bmatrix} I\sum x_i \\ 0 \end{bmatrix}
\end{array}
\tag{2}
$$

In alternative brackets upper rows take place when $\sum\limits_1^n x_i \leq E$, and lower ones - vice version. Let us define $\mathcal{L}_p$ as

$$\mathcal{L}_p = \mathcal{A}_p \cup \mathcal{O}_p \tag{3}$$

Theorem. *$\mathcal{L}_p$ is complete regarding arithmetic operations and distributive multivalue logic follows from it.*

It may be proved constructivly and by direct checking. It's enough to realize double value operations " $\wedge$ ", " $\vee$ ", " $+$ ", " $-$ " on the base of $\mathcal{O}_p$.

Logic and arithmetic operations in $\mathcal{L}_p$.

Disjunction and conjunction operations were not defined in $\mathcal{L}_p$ so far. We can define them following way

$$\begin{aligned} x \wedge y &= K\langle K\langle x,\ Iy\rangle,\ Iy\rangle, \\ x \vee y &= IK\langle K\langle Ix,\ y\rangle,\ y\rangle. \end{aligned} \tag{4}$$

which conicides with their traditional definitions.

$$\begin{aligned} x \wedge y &= min(x,\ y) \\ x \vee y &= max(x,\ y) \end{aligned} \tag{5}$$

Here following rules are accepted:
- Unitary operations " $-$ " and "I" are high priority
- Operations in brackets are done first.
- In a composition of operators the ones from the right side are done first.

It is not hard to check, that operations (2) are distributive:

$$x \wedge (y \vee z) = (x \wedge y) \vee (x \wedge z) \tag{6}$$

For the 4 arithmetic operations we define simple operations of addition and substraction on A_p independent from each other. It is important to note that on A_p operations " $+$ " and " $-$ " are not opposite to each other; as on A_p they are not only non reversible, but also A_p is not closed regarding this operations. It is possible to define a closed binar operation "symmetric diference" on A_p.

$$|x - y| = K\langle K\langle x,\ Iy\rangle,\ K\langle y,\ Ix\rangle\rangle. \tag{7}$$

Substraction for $\forall x,\ y \in A_p$ will be realized by following algorithm.

$$x - y = \langle \bar{S}\langle x,\ y\rangle,\ |x - y|\rangle. \tag{8}$$

The right part of (8) is represented by two parallel, independant operations: $\bar{S}\langle x,\ y\rangle$ defines the sign (in symbols of A_p alphabet), and $|x - y|$ is the modul of substraction.

Let us define the summ in $\mathcal{L}_p$ following way.

$$x + y = \langle S\langle x,\ y\rangle,\ K\langle K\langle x,\ y\rangle,\ K\langle Ix,\ Iy,\ \bar{S}\rangle\rangle\rangle \tag{9}$$

$S\langle x,\ y\rangle$ in conjunctions brackets in the right part of (6) represents digit to be trasfered to "elder" category and the second is the number for the current category.

Physical realization of arithmetic -logic operations in $\mathcal{L}_p$.

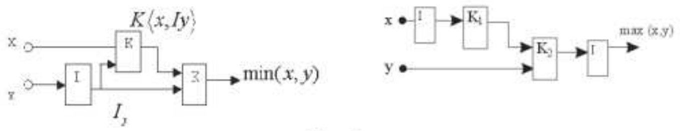
Each operation of $\mathcal{L}_p$ is performed by one polistor, which is marked with the same sign as the operation in schemes.

Hereby we accept following rules.

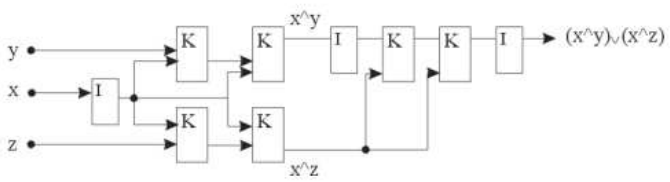
- To the uninterrupted line, connecting two points in a scheme corresponds identical operator in $\mathcal{L}_p$ (wich is often not mentioned in algorithms).

- From the branching point comes out the maximal magnitude of the ones comming in.

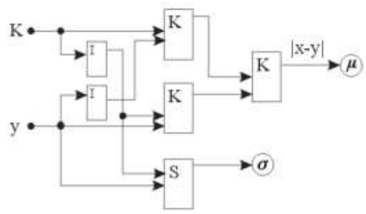
It's not hard to make a physical schem corresponding to the given algorithm on the base of these rules. Schemes realizing algorithms (5), (6) and (8) are given on pic. 1, 2, 3 correspondingly.



Pic. 1



Pic. 2



Pic. 3

References

[1] S. Grigoryan, H. Gulkanyan, H. Karayan, *Using two wavelength beams in the optical monitoring sistems.* Preprint YerPhI, 1571(7)-2001.

[2] R. Feynman, *Quantum mechanikal Computers.* Foundation of Phys., 1986, v.16, N6, p. 507-531.

[3] G. Birkhoff, J. von Neuman, *The Logic of Quantum Mechanics.* Annalis of Math., 1936, v.37 p. 1020.

[4] H. S. Karayan, *Physical Properties of Unhomogneous Semiconducton structures.* PTS, v. 19, N7, 1985, p. 1367

[5] H. Karayan, L. Onanyan, Sh. Martirosyan, *Polistor logic sistem.* Computer science and Information technologies. Yerevan, 2001, p. 422-426.