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Full Length Research Paper

System identification of the logical object and logical acupuncture

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If identification of the stationary logical object (LO) is understood to be its identification with an adequate finite-automation model among set of finite automation, in cases where two completely different aims (object logical structural model construction and device logical control) are being pursued, serious contradictions might arise. With the help of an adequate model received, one tries both to construct appropriate structural model of the computing unit (CU) and consider the object as a control object (CO) to control it. It goes without saying that during the development of the controlling unit of CO, which represents the logical object, its structural model is also being under construction and the object identification, the digital signal processor (DSP), is used as the main central process unit for its high control ability and computing power. Through the introduction of a rough set theory into the multi-sensor information fusion technology, the principal distinction between finite-automation identification for development of the logical structure object model and for logical control of the technological device is shown in this paper. In this work, the conversion of potential dynamic technological object to the guided dynamic object is achieved. It is possible to reach the object of self-control.

Key words: Identification, logic object, modeling, automation, control.

INTRODUCTION

The new logical-mathematical method (super-induction method) for proving common mathematical statements by means of a computer is described. The main features of this method are: (1) An analytical mathematical proof of an unusual reliable inference 'from a single to a common' of the form "IF there exists n* such that Q(n*) holds THEN for all n>n* P(n) is true", where Q and P are some number-theoretical predicates, and (2) a reduction of the proof of the common mathematical statement "P(n) for all n greater than or equal to n*" to a computer searching of a unique single natural number n* (a unique acupuncture point of the infinite natural number series) which possesses a unique collection of number-theoretical properties Q(n*). If such an acupuncture number n* is found, then we can prove the common statement "P(n) for all n greater than or equal to 1", possibly, except for some n less than or equal to n*. Using a so-called cognitive computer graphics (CCG) visualization of abstract number-theoretical objects, the proof can be reduced in many cases to a demonstration of the corresponding CCG-pictures; the strict mathematical proof is reduced to a visually ostensive one. One of such ostensive proofs of real number-theoretical theorems is given. Relations of the super-induction method to other known ones are briefly discussed.

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Abbreviations: LO, Logical object; **CU,** computing unit; **CO,** control object; **CCG,** cognitive computer graphics; **SI,** super-induction; **CD,** controlling device; **SALC,** system of automatic logical control.

GENERALIZATION OF THE COMPLETE MATHEMATICAL INDUCTION

Blaise Pascal's method

It is most fantastic that in general case, there are no restrictions to number-theoretical predicates P and Q. Indeed, you can take any P and any dependence Q= f (P). The most terrible that can occur is that you simply will not

Figure 1. The logical acupuncture of the mathematics infinity of the Godlike series (1): IF, We Have found a single threshold number n*, possessing property Q(n*); THEN, we know all about the behavior of the property P(n) for all n>n* up to infinity.

prove the corresponding EA-Theorem, and nothing more.

For example, let P be an arbitrary number-theoretical predicate. Then, using our choice freedom, we can define a new predicate Q= f (P), say, as follows:

$$Q(n^*) \equiv P(n^*) \,\&\, [\forall\, n>n^*\, [P(n) \rightarrow P(n+1)]], \quad (1)$$

Where, n* is a variable natural number. Since n in Equation (1) is a bound variable, our predicate Q (n*) depends really from n* only.

So, even by a formal way, substituting this Q (n*) in EA-Theorem (2), we obtain:

$$\exists\, n^*\, Q(n^*) \rightarrow \forall\, n>n^*\, P(n) \quad (2)$$

$$\exists\, n^*\, [P(n^*) \,\&\, [\forall\, n>n^*\, [P(n) \rightarrow P(n+1)]]] \rightarrow \forall\, n>n^*\, P(n) \quad (3)$$

As it is easy to see, the expression (4) is the famous complete mathematical induction method by B. Pascal in its more correct notation than its traditional notation:

$$P(n^*) \,\&\, [\forall\, n>n^*\, [P(n) \rightarrow P(n+1)]] \rightarrow \forall\, n>n^*\, P(n) \quad (4)$$

The Super-Induction method works fine in such areas of discrete mathematics where the usual mathematical induction method simply does not work.

Today, the choice of the predicate Q for a given predicate P, and the formulation of the mathematical connection Q= f (P) in the EA-Theorems do not have a theory, that is, they are quite "irrational", that is pure intuitive, informal, actions which realize a natural human-being's aspiration for an unrestricted freedom for the mathematical creativity, in complete accordance with the famous slogan by George Cantor. Of course, till this aspiration leads us out reasonable frames.

Super-induction method

The Super-Induction (SI) method itself is based on the EA-Theorems and has the following absolute, evident and natural formulation (Chase et al., 1990; Cherem and Rugina, 2004):

1. It is necessary to prove a given general statement $\forall n \geq 1\, P(n)$.
2. A conditional EA-statement:

$$\exists n^* Q(n^*) \rightarrow \forall n>n^* P(n), \quad (5)$$

is constructed (is *devised*!), where the number-theoretical predicates Q and P are *distinct*, that is:

Q= f (P) ≠ P.

3. The EA-statemenet (2) is proved analytically (that is, as usually, less general statements are deduced from more general ones).
4. The truth of the *single* statement ∃ n*Q (n*) of the (already, after point 3) EA-Theorem (2) is proved; that is, a natural number n*, possessing the number-theoretical property Q, is found.
5. If we succeed in finding such a unique number n*, then the *proved* truth of the *single* statement ∃n*Q (n*) and the proved truth of the EA-Theorem ∃n* Q (n*) → ∀n>n* P (n) implay (by modus ponens) the authentic truth of the general statement ∀n> n* P (n).
6. The truth of the predicate P (n) is checked for all n ≤ n*:
(a) If ∀n≤n* P (n), then we *have proved* ∀n≥1 P(n);
(b) Otherwise, we find (explicitly!) all elements of the finite exclusive set,
N* = {1 ≤ n ≤ n*: ¬P (n)}, and thus,
7. We prove our general statement in the form:

∀n≥1 P (n), except for n ∈ N*.

So, the logical and mathematical sense of the Super-Induction method is demonstrated in Figure 1.

It is believed that if A. Wiles proved that the Last Fermat's Theorem is true for all powers, r≥2 except for some exclusive set, that is to say, if N* of the r values enumerated all such elements of the set N*, no mathematician would object the statement that A. Wiles has solved (and closed) the problem; because in Mathematics, to solve a common problem of the form ∀n≥1 P(n) denotes not to prove its true or false form, but to indicate explicitly a set of n where P(n) is true and a set of n where P(n) is false. In this sense, it can be said that the mathematical understanding of the common statement notion generalizes the usual understanding of the common statement notion of classical logic.

Structural model of the logical object method

Recall that if A is an alphabet, symbols of which are names of quantum of quantized signal, and if T is a naturally ordered set of nonnegative integers interpreted as the time moments, then $A^T = \{T \to A : 0 \to a_{i1}, 1 \to a_{i2}, \ldots$ (= $a^0 a^1 \ldots$)} is a set of all words above A, in particular, $A^{\{\upsilon\}} = \{\{\upsilon\} \to A : \upsilon \to a (= a^\upsilon)\} = \{a^\upsilon\}$ it is a set of all words above A of unit length and $A^{\varnothing} = \{\varnothing \to A : \to a (= e)\} = \{e\}$, where e is an empty word.
Let X, S, Y be an input alphabet, state alphabet and output alphabet, respectively.

Let us introduce in the general case partial (incompletely defined) functions of transition δ and outputs Mealy λ or Moore λ_M:

$\delta: S^{\{\upsilon\}} \times X^{\{\upsilon\}} \to S^{\{\upsilon+1\}} : \langle s^\upsilon, x^\upsilon \rangle \to s^{\upsilon+1}$,

or (that is admissible from the physical point of view):

$\delta: S^{\{\upsilon\}} \times X^{\{\upsilon\}} \to (S^{\{\upsilon+1\}}) : \langle s^\upsilon, x^\upsilon \rangle \to pred^{\,\upsilon} (s^{\upsilon+1})$,

Where, $(S^{\{\upsilon+1\}})^{\{\upsilon\}} = \{\{v\} \to S^{\{\upsilon+1\}} : \upsilon \to s^{\{\upsilon+1\}}$ (=$pred^{\,\upsilon} (s^{\upsilon+1})$)} and $pred^{\,\upsilon} (s^{\upsilon+1})$)} is a current predication of state-descendant $s^{\upsilon+1}$

$\lambda/\lambda_M : S^{\{\upsilon\}} \times X^{\{\upsilon\}} \to Y^{\{\upsilon\}} : \langle s^\upsilon, [x]^\upsilon \rangle)$ **y^υ:

Where, $[X] = X/\{e\}$ and $[x] = x/e$. Usage of δ transition functions and λ/λ_M outputs instead of more general ratios is justified by the reason that artificial CU (artefact)-the logical circuits, are determinate (in extreme case-pseudo non determinate) whether they include natural, maybe non-determinate LO (natural factors) or not.

Let us consider static LO as an object for which $S = \{s\}$ ($|S| = 1$), that is for which we can formally (but not actually) ignore the transition function ($\delta : \{s\}^{\{\upsilon\}} \times X^{\{\upsilon\}} \to (\{s\}^{\{\upsilon+1\}})^{\{\upsilon\}} : \langle s^\upsilon, x^\upsilon \rangle \to s$) and modify function of Mealy outputs $\lambda: X^{\{\upsilon\}} \to Y^{\{\upsilon\}} : x^\upsilon \to y^\upsilon$ ($\lambda : \{s\}^\upsilon \times X^{\{\upsilon\}} \to Y^{\{\upsilon\}} : \langle s^\upsilon, x^\upsilon \rangle \to y^\upsilon$). There is no point in modification of Moore function, because $\lambda_M: \{s\}^\upsilon \to Y^{\{\upsilon\}} : s \to y^\upsilon$ is a constant output word of unit length. Thus the finite-automation mode of static LO is the ordered triad:

$SL = (X, Y, \lambda)$

Where, $\lambda: X^{\{\upsilon\}} \to Y^{\{\upsilon\}}: x^\upsilon$ ** y^υ or $\lambda: X \to^{\}}: x$ ** y is the output function. It is immediately obvious that behavior of static LO (SLO) is combinatorial.

Structural model of binary static CU which does not include a feedback is directly limited by minimal system of Boolean formulas. Mentioned formulas express Boolean outputs functions in way ensuring determination of the indeterminate values of output functions in order to reach minimal complexity of the projected scheme of CU. Note that without static CU introduction it would be fundamentally impossible to construct its structural model.

Dynamic LO is an object for which $|S| > 1$. Thus the finite-automation model of Dynamic LO is the ordered pentad:

DL =(X, S, Y, δ, λ/λ_m)

It is actually that behavior of dynamic LO is consequent or, incredible as it may seem, it is also combinatorial because if the function of outputs Mealy λ is used and quantity of states of dynamic CU with combinatorial behavior is minimized, then as a result the static object is obtained.

Let us introduce traditionally the transitions generalized function:

$\delta : S^{\{0\}} \times X^{\{0,1\ldots,\,\upsilon\}} \to (S^{\{\upsilon+1\}}) : \langle s^0, x^0, x^1 .\, x.\ ^\upsilon \rangle \to s^{\{\upsilon+1\}}$

Thus, if $x^0 x^1 .x.\ ^\upsilon$ is an admissible output word in state s^0,then

$\delta\,(s^0, x^0, x^1 .\, x.\ ^\upsilon) = \delta(\delta(s^0, x^0, x^1 .\, x.\ ^{\upsilon-1}), x^\upsilon$

If apply on input of LO, being in an initial state s^0 the input word $x^0 x^1 .x.\ ^\upsilon$ admissible in s^0 then the output word corresponding to it will be as follows:

$y^0\, y^1 .\, y.\ ^\upsilon = \lambda\,(s^0, x^0)\, \lambda(s^1, x^1).\, \lambda\,(s^\upsilon, x^\upsilon); [y^0]\, y^1 y^2 .y.\ ^{\upsilon+1} = [\lambda_M\,(s^0)]\, \lambda_M\,(s^2).\ ^0)]\, \lambda_M\,(s^{\upsilon+1})$.

Dynamic LO is understood to be its such consequent behavior at which in case of object controlling x^μ, admissible in s^μ, LO transits from s^μ to $\delta(s^\mu, x^\mu) = s^{\mu+1}$, and gives the response $\lambda_M(s^{\mu+1}) = y^{\mu+1}$, and in this case the state s^μ parameterize the input-output pair (x^μ, y^μ) at μ=0,1, υ. But if the behavior of LO of Mealy type with not minimal quantity of states, or the behavior of LO of Moore type is combinational one, then, notwithstanding the fact that its behavior is similar to consequent behavior, it is pointless to consider it as dynamic one. Therefore we believe that consistently executed transitions between LO states, caused by the different influences, is just necessary, but not sufficient condition of dynamism of the object. Sufficiently LO is its own activity or automatism of realization of the transitions sequence caused by the same influence. That is, if LO will be influenced by words $x^0 x^1 .x.\ ^\upsilon$ at $x^0 = x^1 = \ldots = x = x$ or $x^0 x^1 .x.\ ^{\mu-1}\ x^\mu .x^{\mu+ik} .x.\ ^{\mu+(i+1)k-1-}$at $x^0 = x^1 = \ldots = x^{\mu-1} = x^{(i+1)k-1} = x$, $i = 1,2\ldots$, then respectively, either:

$$\delta(s^0, x^0 x^1 .x.\ ^\upsilon) = s^{\upsilon+1} \,\&\, s^\nu \neq s^{\nu+1} (\nu = 0, 1, ., \upsilon.\ ) \,\&\, \delta(s^{\upsilon+1}, x^\upsilon) = s^{\upsilon+1},$$

That is, the acyclic sequence of transitions ends in a steady (equilibrium) state $s^{\upsilon+1}$ as regard to $x.\ ^\upsilon.$, or

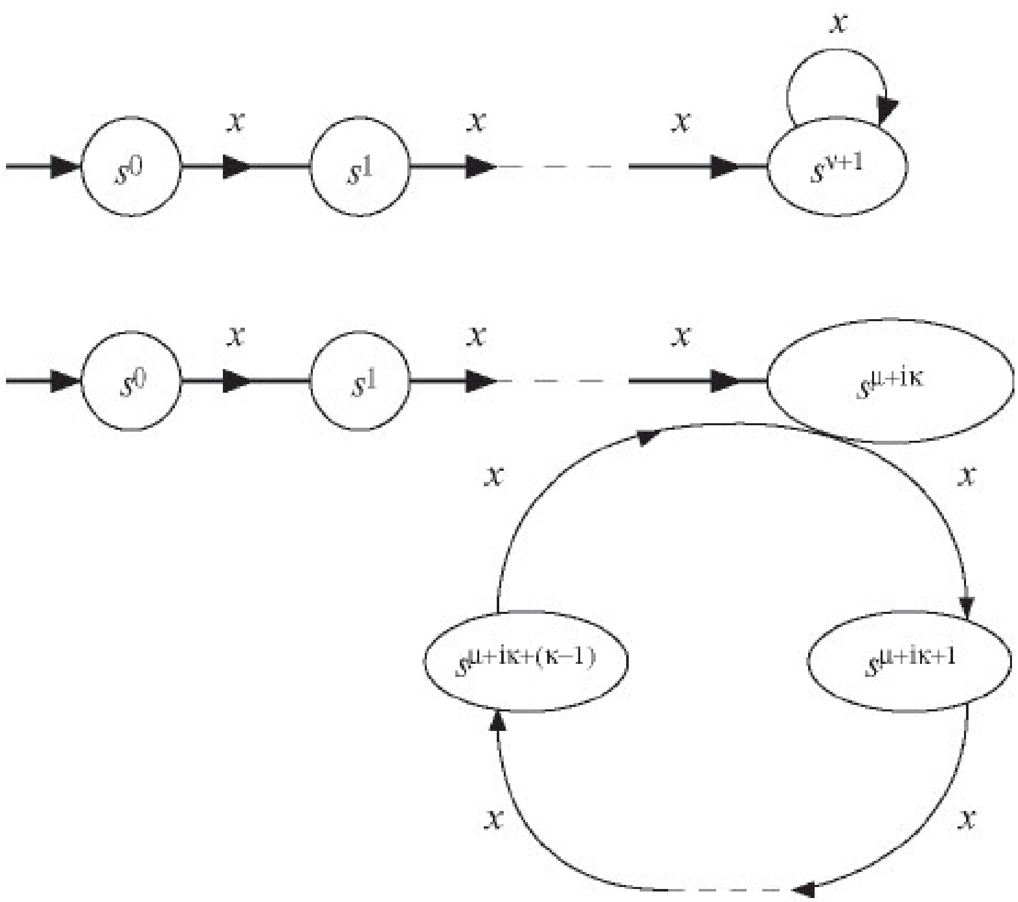

Figure 2. Sufficient conditions of LO dynamism.

$$\delta\left(s^{0}, x^{0}x^{1} . x. ^{\mu-1}\right) = s^{\mu} = \delta\left(s^{\mu+i\kappa}, x^{\mu+i\kappa}x^{\mu+i\kappa+1} . x. ^{\mu+(i+1)\kappa-1}\right) = s^{\mu+(i+1)\kappa}$$

and

$$s^{\vartheta} \neq s^{\vartheta+1} \quad (\vartheta = 0, 1, ., \mu - 1) \& s^{\mu+i\kappa+j} \neq s^{\mu+i\kappa}$$

the object, having passed acyclic sequence of transitions, gets in its final state in infinite (practically to final number of times) repeated cycle of states with period κ ($\kappa > 0$) (Figure 2).For example, in the given table of transitions (Table 1) dynamism of LO is illustrated by arrows.

The structural model of binary dynamic CU, a prototype (contains feedback) represents a scheme of canonic decomposition of required binary static structural model which is projected in such a way that at excitation of a corresponding binary dynamic substitute of the prototype (as a rule, the parallel register of so-called remembering binary modules), it carried out transitions between own states, similar to transitions between the prototype states. The structure of the initial decomposition also includes binary output structural model (Chase et al., 1990; Birdie et al., 2007).

As the substitute of set CU is also a dynamic CU, the sufficient conditions of dynamism are not obvious, because the structural model of LO automatically pass the set trajectory under the influence of the same control.

Finite-automation model of control object method

Considering CO as natural object, it is accepted for non-determinate object (at that the accident is caused by the influences on CO of implicit disturbances), or for determinate with obviously expressed disturbances (Chong and Rugina, 2003). Thus, it is traditionally assumed that the ratio, in particular function of transitions δ, looks like:

$$\delta : S^{\{v\}} \times U^{\{v\}} \times S^{\{v+1\}} : \langle s^{v}, x^{v}, s^{v+1} \rangle \quad (1)$$

or:

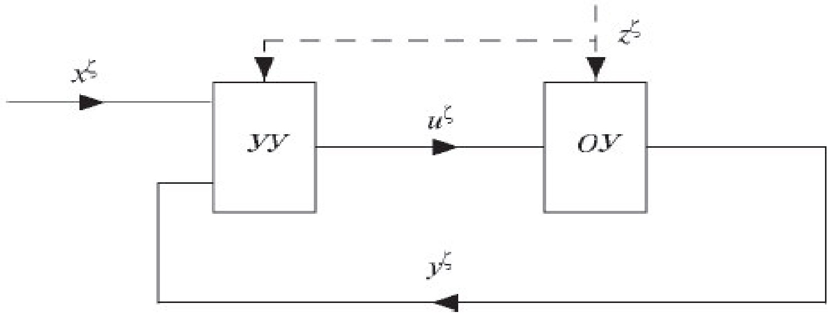

Figure 3. Automatic logic control system.

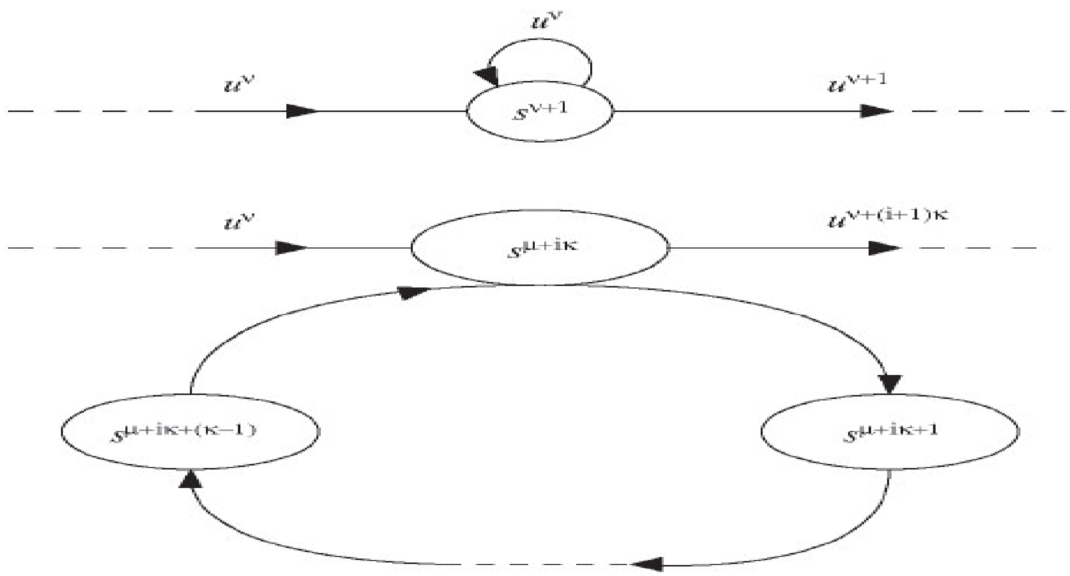

Figure 4. Logical control conflicts.

$$\delta : S^{\{v\}} \times U^{\{v\}} \times Z^{\{v\}} \rightarrow S^{\{v+1\}} : \langle s^{v}, x^{v}, s^{v+1} \rangle \rightarrow s^{\{v+1\}}, \tag{2}$$

Where, *U, Z* is alphabet of controls and obvious disturbances, respectively. It is also assumed that for injective and in particular for identical Moore outputs function λ_M, the following is valid:

$$\lambda_M : S^{\{v+1\}} \rightarrow Y^{\{v+1\}} : s^{v} \rightarrow y^{v}$$

So, it is assumed that the ordered pentad is the final-automatic model of CO.

CL = (U (Z), S.y, δ, λ_M).

As a rule, possessing the finite automation, one tries to find the finite automation model of artificial, that is, determined, controlling device (CD), believing that its transitions between own states are similar to transitions between states of CO that is obviously pointless. Because if to accept Mealy finite automaton for CD model, then, minimising number of its states, we receive static CD (Deutsch, 1994) that quite corresponds to control according to Bellman (Dolby and Chien, 2000) because for definition of current control u^{ζ} it is enough to have a current state $s^{\zeta} = \lambda_M^{-1}(y^{\zeta})$. However, the standard understanding of the logical control, as the actions made on CO by the controlling device in the system of automatic logical control (SALC), (Figure 3) by means of controls sequence face with the invincible obstacle. The given obstacle is what $s^{\upsilon+1}$ steady relative u^{υ} to, it can be left only in the event if CD will be constrained to give such control $u^{\upsilon+1}$ under $s^{\upsilon+1}$, what $u^{\upsilon+1} \neq = u^{\upsilon}$.

In other case, if using control $u^{\mu+ik}$ we get from the state $s^{\mu+ik}$ into finite circuit with period *k* it can be left from the state $s^{\mu+ik}$ only by means of such control $u^{\mu+(i+1)k}$, what $u^{\mu+ik} \neq u^{\mu+(i+1)k}$ (Figure 4).

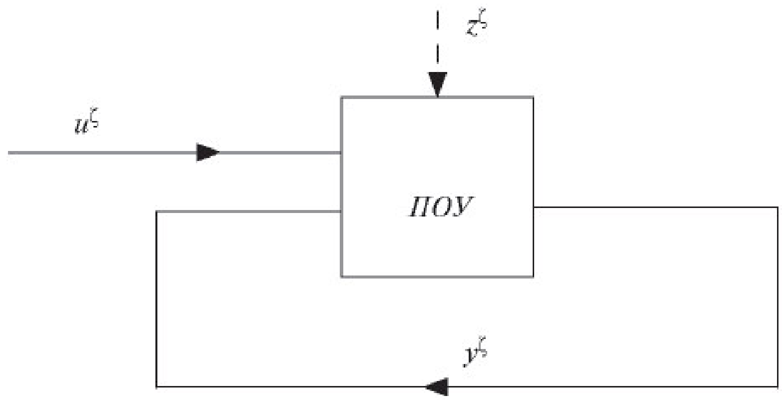

Figure 5. Dynamic CO block scheme.

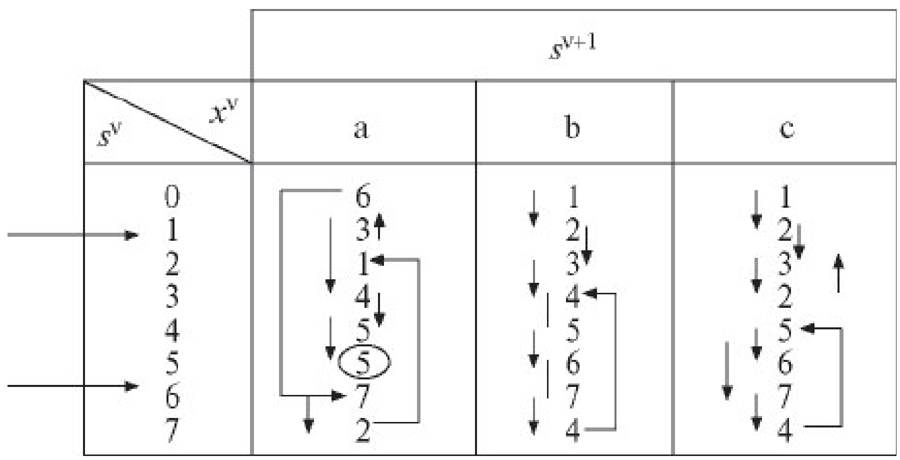

Figure 6. Sufficient condition of LO dynamism.

The given critical weakness of the logical control being used lies in the assumption that the sufficient conditions of CO dynamism are satisfied. And this connected with the fact that the CD designers who had previously created the structural models of CU dealt only with the dynamic objects, and that is why it is reasonable that, they consider the technological objects as dynamic ones. CU designer during identification of CO unwittingly tries to add to the control object the dynamism property. However, the set technological object is not the dynamic, but only potentially dynamic. Therefore, it is necessary to reformulate the task of logical control by potentially dynamic CO ensuring the CO dynamism.

Thus, the finite-automation dynamic model of set potentially dynamic control object (PCO, Figure 5), or control pseudo-object, is the ordered pentad:

CPL= (U, S, δ, λ_m).

The ratio, in particular, function of transitions δ of the given pentad, satisfying the sufficient condition of dynamism, looks like (Figure 6):

$$\delta : S^{\{v\}} \times U^{\{v\}} \times Y^{\{v\}} \to S^{\{v+1\}} : \langle s^{v}, u^{v}, \lambda_M^{-1}(y^{v}), s^{v+1} \rangle,$$

or:

$$\delta : S^{\{v\}} \times U^{\{v\}} \times Y^{\{v\}} \times Z^{\{v\}} \to S^{\{v+1\}} : \langle s^{v}, u^{v}, \lambda_M^{-1}(y^{v}), z^{v} \rangle ** s^{v+1},$$

Where, λ_M is the injective, especially identical outputs function $\lambda_M : S^{\{v\}} \to Y^{\{v\}} : s^{v} ** y^{v}$.

Let, for example, PCO be set by the table of transitions. Then it is possible to construct the table of transitions of the dynamic CO.

CONCLUSION

Thus, the present work reveals the problem of logical object identification, taking into account the solving of two tasks, that is: constructions of logical structural model of the object and technological device logical control. We considered issues of construction of control object finite-automation model. We demonstrated the transformation of set potentially dynamic technological object (pseudo-object) into dynamic control object.

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