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51. Internationales Wissenschaftliches Kolloquium
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INTEGRATION OF MANAGEMENT SYSTEMS FOR CONSTRUCTION HOLDINGS ON THE BASIS OF NEURO NETWORK COORDINATION

Abstract: the article deals with the problems of integration of technological management systems for construction holdings with a continuous cycle of processing and production of small-batch and separate units. The integral system of holding management implies imformative representation of subdivisions with different automation levels. These subdivisions are territorially allocated and initially have the required completeness of their own information procedures; which however appears insufficient for business processes in the holding structure. The article describes reconfiguration algorithms for management systems of technical equipment, which are based on results of operation state monitoring by external and inner sensors. The article also gives special consideration to integration process of local systems of subdivisions with distribution system of the holding with intellectual and forecasting management, based on neuro network coordination according to the criteria of minimization of global and/or local risk of business processes.

Key words: management system, neuro network coordination, business-process risk.

1. Introduction

Transition to the holding organization structure facilitates the control of business processes, which vary in volumes and types, within integral frames. Potentially construction holding allows to dynamically extend production capacity, meet the demands of new markets and technologies, solve interfunctional production problems. Special conditions are created to realize efficient modernization and introduce management systems for technological installations of individual units, small-batch production lines under complex control of the automation system. However, hierarchic management structure brings about reciprocal successively parallel information flows, non-synchronized in time; thus decision is made locally without considering global efficiency criterion. Taking into account modern development of computer technologies, it is proposed to integrate programmed modules of multilayer neuro networking into holding automation system to eliminate indeterminate conditions, to choose configuration parameters of equipment by dynamic latent neuron layers online, to synchronize knowledge information of management systems for circular successively parallel neuro structures.

Vector perceptron is applied in program modules of multilayer neuro network in automation system of holding. Two types of vectors are essential to increase the range of possibilities for choosing management system state from several potentially possible:

$W^{1,1}$ – current weight of input state vector of I_p components of p management system,

b^1 – fixed weight of respective component of p management system, which depends on its technical characteristics,

a^1 – activation vector of p component, which is part of the chosen state.

The choice of active state is made according to the maximum value of a^1 for parallel algorithms: $a^1 = \max\left(I^p \cdot W^{1,1} + b^1\right)$. In case there is a difficulty to distinguish maximum, we choose minimal a^1: $a^1 = \min\left(I^p \cdot W^{1,1} + b^1\right)$.

A multilayer perceptron network is used for client-server realization, perceptrons being fulfilled by every client: $S^1 = K$. To achieve this, we perform a synchronized transmission of the input vector of i-condition provided the current $w^{1,1}$ - weight is equal for each vector. Choice of state is realized in this case as: $a^1 = \max\left(i \cdot w^{1,1} + b_s^1\right)\Big|_{a_s^1 = a_s^s}$, in which $b^1{}_s$ - fixed weight of respective component p of management system for client S, a_s^1 and a_s^s - vectors of condition choice for all S client.

2. Efficient Holding Management with forecast of operations

Management system of construction holding with continuous cycle of processing and production of small-batch and individual units is based upon technologies regulated by normative documents. Product quality depends on synchronized supply of essential raw material, which in reality results in machine idle time till the end of preparatory operations. The main function of efficient management system is to coordinate successively working installations, redistribution of raw material between production lines and shift of settings accumulators to quality standards. The indicated situations cannot be realized within the frames of known efficient control systems.
Let us analize forecast of operation realization, performed by Hamming's self-organizing neuro network, in which weight coefficients of neurons are set on the basis of prior information, concerning the topology of technological lines. An associating iteration forecast results in the only variant of switching on and synchronization of installations and lines.
Neuro network of the efficient control loop consists of a set of static neurons:

$$x(k) = \left[1, x(k), x(k-1), \ldots x(k-(N-1)), y(k-P), y(k-P+1), \ldots y(k-1)\right],$$

Which correspond with k-installations of enterprise with N-delays; the set of dynamic neurons $y(k-P)$, which correspond with the lines, characterized by P delays; matrix of static neuron $W = \left[W_{kl}\right]$ feedback, which reflects interconnection between installations; matrix of dynamic neuron $T = \left[T_{ij}\right]$ feedback, which reflects current productivity; matrices of cross connections $H^x = \left[H_{ik}^y\right]$, $H^x = \left[H_{ki}^y\right]$, $H_{ik}^y = H_{ik}^x$ between the sets of k and y neurons, which reflect operator's efficiency or qualification. Dynamics of resulting neuro network is described as:

$$Y_k = \sum_{j=1}^{N} H_{kj}^x \cdot V_j - I_k^x + \sum_{l=1}^{N-P} W_{kl} \cdot V_l^x ,$$

$$dU_i \big/ dt = -U_i \big/ S + \sum_{j=1}^{N} T_{ij} \cdot V_j - I_i^y + \sum_{i=1}^{N-P} H_{il}^y \cdot V_l^x ,$$

in which Y_k and U_i are y-line production and amount of prepared raw material of k-installation respectively; V_l^S is the function, which describes state neuron activation; V_j is discrete time model of dynamic neuron output defined according to duration of S production shift.
To choose the required amount of delays $N = P = 3$ we calculate the obtained output produced from provided raw material, the predicted output received from the loaded raw material and the predicted quantity of raw material for the required output for every installation and production line.
Program modules of prediction processing are accomplished in Pascal and C++ program languages and supplement the specialized library of mathematic extension of enterprise management system.

3. Synchronization of Technological Equipment

Let us consider acceleration of control operations for technological equipment with synchronization according to current state. The starting technological process belongs to quasi-parallel with fixed interval of digitization of management by local controller. The time diagram of production quality control in three parameters is shown in Fig. 1. On executing SM program module by P1 controller, values of analog–digital convertors of A – Input C sensors are set into successively, current parameter values are calculated and managing Out A – Out C influences are formed. Taking into consideration the existence of controllers in each installation and the technological diagram of quality control, parallel execution of indicated operations by three controllers on introduction of synchronization points before managing influences is possible, for what the existed SM module is substituted by PM synchronization module (Fig. 2). It should be noted that the main computing modules remain algorithmically unchanged, and PM module differ from SM module in an extra interval of digitization. Taking into account directly proportional necessity in time of quasi-parallel operations execution from their quantity, one may state that in proposed successively parallel mode an extra synchronization segment will need some small extra time resource, and the received acceleration of operation execution will be comparable with a theoretically attainable acceleration coefficient: $k_t = \frac{t_{sm}}{t_{pm}} = \frac{t_{sm} \cdot P}{t_{sm}} = 3$,

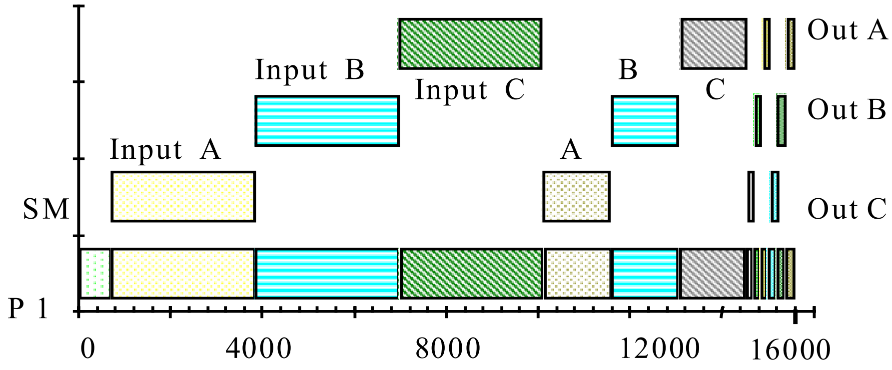

Fig. 1

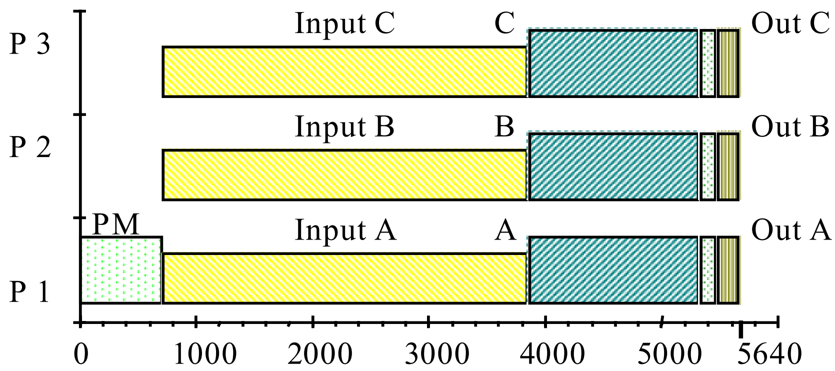

Fig. 2

where t_{sm}, t_{pm} are durations of operation performance in the starting and proposed variants;

P - the number of controllers.

The actually attained acceleration coefficient of operation performing of the line of three technological installations is defined on the basis of a technological map of a system monitor in intervals of management digitization:

$$k_r = \frac{t_{sm} - t_{sc}}{t_{P1} - t_{sc} + t_{pc}} = \frac{15600 - 710}{5640 - 710 - 80} = 2.97,$$

where t_{sc}, t_{pc} are durations of SM and PM modules consequently;

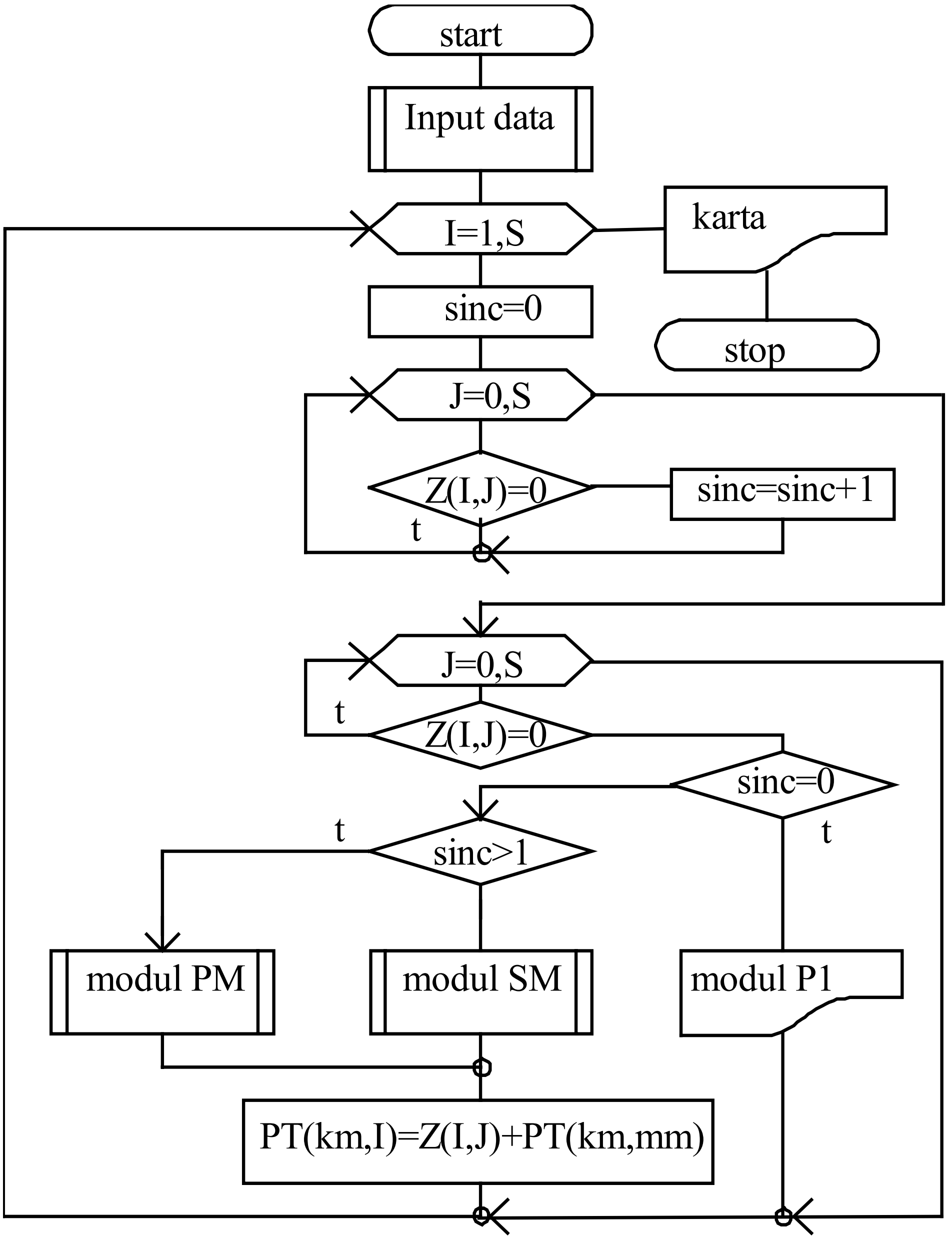

Fig. 3

t_{P1} - duration of expectation of a synchronization point.

Operations distribution, computing of module duration and preparation of the technological map is performed on the basis of the algorithm in Fig. 3. Input data are prepared in the form of matrix of space states of installations with indication of potentially possible operations.

The algorithm is included into the composition of the efficient control of a production line or of equipment with several installations equipped with programmed controllers. As a result, when changing state or productivity, readjustment or stoppage of technological lines is not needed.

4. The Model of Integration of Local Management Systems with Neuro Networking Coordination

When integrating local management systems in the distribution system to preserve linear dependence of operation processing speed, the number of active technological lines with distance monitoring is limited. The necessity of preservation of business process productivity in case of failures or malfunctions of installations leads to an extra equipment change-over or stoppage. The creating roundabout or reserve information flows must be checked up on correctness in all state space. Such a task is polynomial, and becomes unsolved for the complex automation system of construction holding on the actual time scale. Heuristic algorithms on the method of branches and bounds or dynamic programming give an approximate solution only in subset of state space without considering all parameters of the used technological process. As a result an installation with an unstable malfunction can be used, which will lead to control instability of the entire business process.

Let us consider an integration model with predicting management on the basis of Hopfield's self-organizing neuro network in which weight coefficients of neurons are set on the basis of a priori information about local management systems topology. The network consists of two layers (Fig. 4); each layer has m neurons corresponding to installations of technological equipment. Neurons of the first layer have X_n inputs, to which information about the quantity of successful installation usages in active business process is sent. Neurons of the second layer are interconnected by inhibitory synaptenly information flows. When operating equipment skillfully, the following values are assigned to weight coefficients of the first layer and the active function threshold:

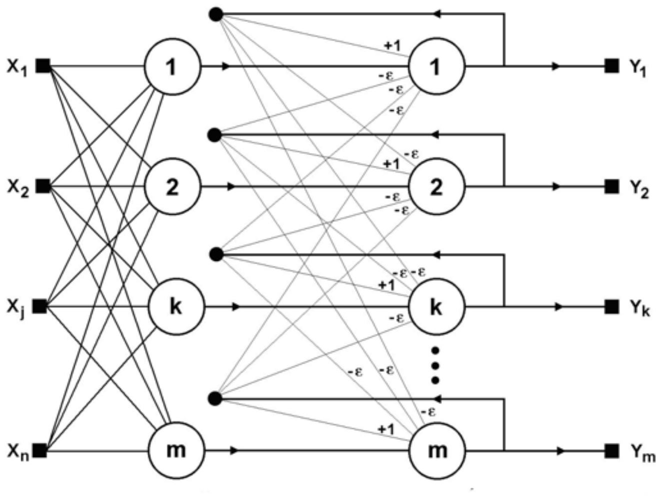

Fig. 4

$$w_{ik} = \frac{x_i^k}{2},\ i = 0, n-1;\ k = 0, m-1;\ T_k = \frac{n}{2}.$$

Here x_i^k - i-element of k-installation of technological equipment.

Weight coefficients of inhibitory inputs of the second layer equal to inverse value of operating-time to failure of the installation modeled by a neuron. During the first putting in operation of a technological line, certificate characteristics of installations are registered into their initial parameter vector: $X = \{x_i : i = 0, n-1\}$.

Initial states of the first layer and outputs of the second neuron layer are equal:

$$y_j^{(1)} = s_j^{(1)} = \sum_{i=0}^{n-1} w_{ij} x_i + T_j\ ;\ j = 0, m-1;\ y_j^{(2)} = y_j^{(1)}.$$

Current states and output values of the second layer neurons are calculated as following:

$$s_j^{(2)}(p+1) = y_j(p) - \varepsilon \sum_{k=0}^{m-1} y_k^{(2)}(p), k \neq j, j = 0, m-1;$$

$$y_j^{(2)}(p+1) = f\left[s_j^{(2)}(p+1)\right], j = 0, m-1.$$

During the check of output changes of the second layer neurons, the threshold of an activation function $f[s]$is coordinated by operation of neurons forming an information flow of an active technological line of the business process. To minimize errors of equipment state prediction one uses Cohen's algorithm for neuron input parameters coming from outputs of the preceding $y_j^{(n-1)}$ layer and for its weight coefficients corresponding to current relative coefficients of malfunctions of technological equipment installations:

$$w_{ij}(t) = w_{ij}(t-1) + \alpha \cdot \left[y_i^{(n-1)} - w_{ij}(t-1)\right],$$

where $y_j^{(n-1)}$ is an output value of i-neuron of (n-1)-layer i, *(n-1)*, $y_j^{(n)}-$ is an output value of j-neuron of n-layer; $w_{ij}(t)$ and $w_{ij}(t-1)$ are weight coefficients of the output connecting these neurons, on iterations *t* and *t-1* correspondingly; α - coefficient of instruction speed.

The considered neuro network co-ordination and instruction method are orientated on selection of installations with minimal malfunction coefficients. In the process of the technological line functioning $w_{ij}(t)$ weight coefficients are set into the operative control loop of the complex automated holding system to decide upon modernization or equipment renewal and possibility of its usage for production expansion.

To detect equipment with actually expiring resource and unsafe equipment the third latent neuron is introduced similar to the Hamming's neuro network type. Current states and neuron output values of this layer are calculated in the following way:

$$s_j^{(3)}(p+1) = y_j(p) + \varepsilon \sum_{k=0}^{m-1} y_k^{(3)}(p), k \neq j, j = 0, m-1;$$

$$y_j^{(3)}(p+1) = f\left[s_j^{(3)}(p+1)\right], j = 0, m-1, \sum_j y_j^{(3)} \in N .$$

The results of the third neuron layer are used to predict technological risks, estimate and calculate losses of business processes.

5. The model of information representation of technological process

It is necessary to create excess information flows in order to carry out technological process without stops in business process between local control systems. Circular structures possess minimal excessiveness of additional equipment. To realize the technological process it is necessary to analyze available information flows; this process has logically-temporary character.

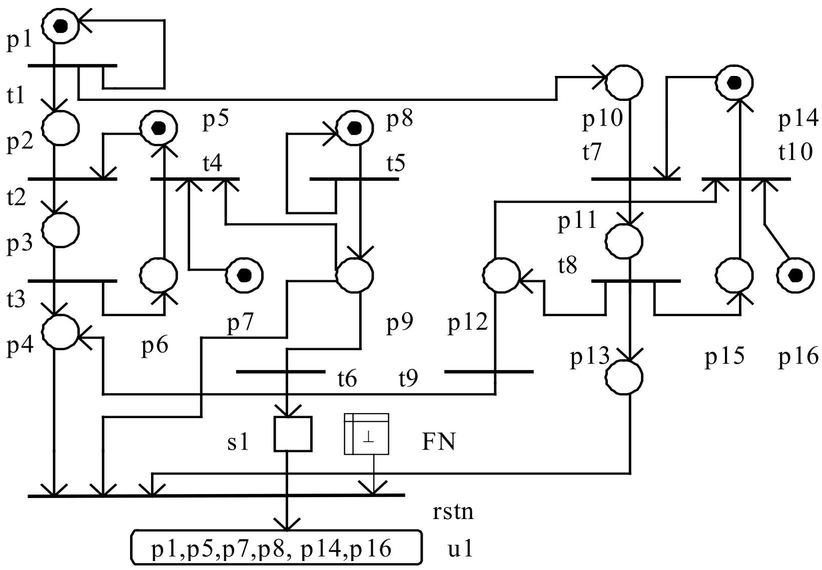

Fig. 5

To eliminate NP we offer to perform the process according to information about unstable operation time, which is accumulated during the process. To achieve this, into local management systems we introduce the restoration function with nonlinear shift relation FN, equivalent to elementary neuron (Fig. 5). This results in dynamic choice of potentially safe installation, i.e. we optimize technological process according to criteria of maximum controllability online. Taking into account logically-temporary character of restoration, the extended temporary network of Petry is used as a model. Activation of information flow out of abundance of all available ones is performed in accordance with the following rule:

$$AD = \left(AM \wedge \overline{rstn}\right) \vee \left(AR \wedge \overline{AM}\right) \vee \left(AS \wedge \overline{AR}\right).$$

In which *rstn* – is a restoration function, which activates information flow;

$AM = \{t_1, t_2, t_3\}$, $AR = \{t_1, t_2, t_3, t_4\}$, $AS = \{t_1, t_2, t_3, t_4, t_5\}$ are algorithms of basic, contiguous and circular information exchange.

Logical and temporary corretness of technological process restoration in the offered model can be realized through the following algorithm:

$$\forall S_i \in SPRE(rstn) : (M_g(S_i) \geq 1) \wedge ((t_{\min} \leq \tau_{rstn} \leq t_{\max}) \vee (\tau_{rstn} \geq t_{rstn} + T_{rstn})) : k_{rstn} = 1,$$

In which *SPRE* (*rstn*) – represent numerous management S_i conditions of *rstn* function;

M_g – current state of the model;

$\tau_{rstn} = \min(FN)$ – minimal value of operation *rstn* duration for installation with unstable time of operations;

$t_{\min}$, $t_{\max}$, T_{rstn} – minimum, maximum operation time and mathematical forecast of restoration duration;

k_{rstn} – indicator of further state change M_{g+1} in a current structure of information exchange.

The state $M_{g+1}(p) = M_{rstn}(p)$ after restoration is calculated through:

$$M_{rstn}(p) : (M_{rstn}(p_j) = 0 \,|\, p_j \in PPRE(rstn)) \wedge (M_{rstn}(p_l) = O(rstn, p_l) \,|$$

$$|\; p_l \in PPOST(rstn) \wedge (M_{rstn}(p)) - M_g(p) \,|$$

$$|\, p \in PPRE(rstn)) \wedge (V_{g+1} \geq V_g + VL((t_{\min} \leq \tau_{rstn} \leq t_{\max}) \vee (\tau_{rstn} \geq t_{rstn} + T_{rstn}))),$$

In which $PPRE(rstn)$, $PPOST(rstn)$ – represent numerous input and output conditions p_i of the operationrstn;

$O(rstn, p_i)$ – function of the output realization of the operation *rstn*;

V_g, V_{g+1}, VL – values of the online sensor in conditions M_g, M_{g+1} and function of time parameters extraction proceeding from logical representation of the operation *rstn*.

Thus, restoration of technological process is realized through synthesized dynamic one-layer neuro network out of three neurons; which models potential information flows.

6. Conclusion

The above considered ways of integration territorially distributed local management systems of technological lines in construction holdings with complex automated management system help to conform the standards, required from system integration: synchronically change indices at all levels of automation, reduce quantity and volume of control procedures, maintain stability and integrity of processing chains in business processes, create conditions for flexible extension and modernization of holding production capacities, use available equipment and staff. The offered models and algorithms don't contradict the prescribed technologies and help to realize neuro network coordination which eliminates excessiveness and controversy in the oncoming information flows of hierarchic management systems; synchronizes processing chains of business processes, which reduces costs and improves products quality; increases coefficient of equipment exploitation, reduces error influence of equipment operators, makes a forecast about equipment state, reduces the risk of business process.

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