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MATHEMATICAL ANALYSIS OF BIBLIOMETRICAL INDICES OF PUBLISHED WORKS ON NEUROPHYSIOLOCAL EFFECTS OF NON-IONIZED RADIATION OF DIFFERENT KINDS (MEDLINE-INTERNET)

Abstract. Bibliometrical data on neurophysiological published works carried out with application of non-ionized radiation of different kinds (EMF, MW, MF and EF) are presented. Quantitative characteristics of published works of choose subdivisions during 35-year time interval (1966-2000) be considered. Dynamics of number of published works of these trends is analyzed. Conclusion about prospects of investigations of neurophysiological effects of non-ionizing radiation is done.

Keywords. Published work, non-ionized radiation, neurophysiological, bibliometrical indices, nervous system.

Introduction

Biological phenomena of non-ionizing radiation (NIR) of different kinds interested humanity for many centuries [15]. Development of modern society, particularity in XX century, led to extensive use of these physical factors of wide frequency and intensity range. Sources of NIR are radio communications, various radar systems, some technological processes at enterprises, transport, research instruments, wiring, home electric appliances, and etc. Technical progress promotes expansion of investigations of influence of NIR on organism [15].

The nervous system is of great significance in reactions of organism to NIR. Neurophysiological alterations made by these factors were considered in series of our works. Our pioneering investigations revealed predominant role of direct action of NIR of different kinds on brain structures, personally on the cortex, in origin of reactions of organism [1-3]. Later we considered evoked and background activity of single neurons [4-6] and pattern of pulse flows of neuronal populations at action of NIR [6, 7, 10-13].

Towards middle of the seventies years of XX century probably more 5 thousand published works on biological effects of NIR were accumulated [15]. 20 years later the number of such published works was believed to reach 10 thousand [6, 16]. In 2000 their number exceeded 21

thousand [8, 14].

Bibliometrical analysis of published works on biological action of NIR was not carried out up to now. Therefore we began bibliometrical researches on this problem. The state of investigations of biological effects of NIR was examined be means of internets databases. Information accumulated in world on electromagnetic biology during 35-year period in the later half of the XX century (1966-2000) was considered. Quantitative characteristics of published works about biological influence of NIR of different kinds, including electromagnetic (EMF), magnetic (MF), and electrical (EF) fields, was analyzed. Moreover especially biological effects of microwaves (MW) were selected because this factor was in the center of attention of researchers in the middle of the XX century.

The present work is devoted to examination of quantitative characteristics of published works on neurophysiological effects of NIR of these kinds.

Some results of our bibliometrical investigations were already presented in papers [8, 9, 14].

Materials and methods

Quantitative characteristics of published works on biological action of NIR in world during 35-year period in the later half of the XX century (1966-2000) were considered. Investigations were carried out by means of mainly the database "Medline" accessible through Internet. The numbers of published works of observed trends were determined for every analyzed years with the aid of corresponding key words.

At statistical analysis of the material the comparisons of sampling fractions of obtained data from their sum, from the total number of works with application of NIR, and from the total number of neurophysiological works are used. For calculations of statistical significance of distinctions between indicated data criterion for selective portions of variants was applied.

Results

In considered 35-yaer period the total number of published works carried out in different neurophysiological objects reached 1401300. Number of works on biological action of NIR was 21606. The numbers of works performed with application EMF, MW, MF and EF were 6001, 6920, 5316 and 3369 correspondingly. Number of neurophysiological

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works on effects of NIR was 5935, what was equal to 1.54% from total number of neurophysiological works and 27.46% from total number of work with NIR.

General characteristics of received totalities are presented in table 1. Sampling fractions of obtained data from their sum, from the total number of works with application of NIR and from the total number of neurophysiological works are shown in table 2. Statistical comparison of indicated sampling fractions is reflected in table 3. Dynamics of the number of published neurophysiological works performed with application NIR of different kinds (EMF, MW, MF and EF) and dynamics of the considered sampling fractions (%) are demonstrated in tables 4-7.

Table 1

General data on the number of published neurophysiological works carried with application of NIR of different kinds during 35-year period

Factors	Characteristics of totalities			
	Total number of papers in 35 years	Sampling variance	Average number of papers in 1 year	Standard deviation
1	2152	4346.90	61.49	11.14
2	1435	640.52	41.00	4.27
3	1649	3321.16	47.11	9.74
4	699	507.49	19.97	3.80
5	5935	21965.08	169.57	25.05

Application: 1 - EMF, 2 - MW, 3 - MF, 4 - EF, 5- sum.

Table 1 shows that among published neurophysiological works on research of action of NIR the predominance of works with application of EMF took place in investigated period. The least number observed in works on analysis influence of EF.

Table 2 demonstrates that sampling fraction (%) from total data in published neurophysiological works with NIR (5935) prevailed in works carried out with EMF. Similar result was found at calculation of sampling fractions (%) from total number of works on biological action NIR (21606) and at calculation of sampling fractions from (%) total number of neurophysiological works (1401300).

Data of statistical analysis represented in table 3 proved existence and peculiarity of distinctions between different sampling fractions de-

scribed above. Indeed, published neurophysiological works carried out with application of EMF, MW, MF and EF had statistically different sampling fractions from their sum, from the total number of works with application of NIR from the total number of neurophysiological works.

Table 2

Sampling fractions (%) of received data from their sum, from the total number of works with application of NIR from the total number of neurophysiological works

Factors	Characteristics of totalities		
	Sampling fraction from these data (%)	Sampling fraction from total data with NIR (%)	Sampling fraction from number of neurophysiological works (%)
1	36.25	9.96	0.15
2	24.18	6.64	0.10
3	27.78	7.63	0.12
4	11.78	3.23	0.05
5	100	27.47	0.42

Application: as in table 1.

Dynamics of the observed bibliometrical indices during 35-year period is presented in tables 4-7. Table 4 gave dynamics of the concrete numbers of published neurophysiological works carried out with application of NIR of different kinds during 35-year period. Table 5 reflects dynamics of the sampling fractions (%) of published neurophysiological works carried out with application of separate physical factors five-year periods from their total number. Table 6 shows dynamics of the sampling fractions (%) of published neurophysiological works made with employment of NIR of different kinds in single five-year periods from total number of works with of these factors during 35-year period. Table 7 demonstrates dynamics of the sampling fractions (%) of neurophysiological published works with NIR of different kinds in single five-year periods from total number of neurophysiological works during 35-year period.

The considerable increase of the numbers of published neurophysiological works carried out with all different kinds of NIR gradually developed during 35-year period (table 4). Clearly this event took place in case of application of EMF, MF, and EF. A number of works with MW

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increased too. However such phenomenon came to its close at the last analyzed five-year period.

Table 3

Comparison of sampling fractions of received data from their sum, from the total number of works with application of NIR from the total number of neurophysiological works

Factors	Comparison of sampling fraction of totalities		
	Comparison of sampling fraction from these data (*U*)	Comparison of sampling fraction from total data with NIR (*U*)	Comparison of sampling fractions from number of neurophysiological works (*U*)
1 - 2	14.33	12.47	11.72
1 - 3	9.86	8.52	8.37
1 - 4	32.19	29.10	27.62
2 - 3	4.47	3.95	3.35
2 - 4	17.87	19.63	15.90
3 - 4	22.33	20.58	19.25

Application: statistically significant distinctions between distributions are underlined ($U>1.96$ corresponds to $p<0.05$, $U>2.58$ corresponds to $p<0.01$); the other designations as in table 1.

Table 4

Dynamics of the number of published neurophysiological works carried out with application of NIR of different kinds during 35-year period

Factors	Indices for different five-year periods						
	1966-70	1971-75	1976-80	1981-85	1986-90	1991-95	1996-2000
1	18	31	69	136	387	687	824
2	16	97	213	250	282	313	264
3	10	22	50	125	312	456	674
4	6	18	39	65	118	173	280
5	50	168	371	576	1099	1629	2042

Application: as in table 1.

Dynamics of the sampling fractions (%) of different published works in single five-year periods from their total number was complex and unequal (table 5). Works with MW prevailed in 70-80 years. The

least sampling fractions were at published neurophysiological works with application of EF.

Table 5

Dynamics of the sampling fractions (%) of published neurophysiological works carried out with application of NIR of different kinds in single five-year periods from their total number

Factors	Indices for different five-year periods						
	1966-70	1971-75	1976-80	1981-85	1986-90	1991-95	1996-2000
1	36.00	18.45	18.60	23.61	35.31	42.17	40.35
2	32.00	57.74	57.41	43.40	25.66	19.21	12.93
3	20.00	13.10	13.48	21.70	28.39	27.99	33.01
4	12.00	10.71	10.51	11.28	10.74	10.62	13.71
5	100	100	100	100	100	100	100

Application: as in table 1.

Table 6

Dynamics of the sampling fractions (%) of published neurophysiological works carried out with application of NIR of different kinds in single five-year periods from total number of works with application of these factors during 35-year period

Factors	Indices for different five-years periods						
	1966-70	1971-75	1976-80	1981-85	1986-90	1991-95	1996-2000
1	33.96	25.20	17.42	21.09	39.41	41.01	38.74
2	6.87	20.68	26.14	23.74	23.58	19.53	17.02
3	17.86	16.06	17.24	23.58	32.88	33.90	33.55
4	11.77	20.46	15.35	18.16	18.02	20.14	25.36
5	12.72	20.56	21.14	22.27	29.06	29.72	30.07

Application: as in table 1.

Pattern of dynamics of the sampling fractions (%) of neurophysiological published works carried out with application of EMF, MW, MF and EF during 35-year period from the total number of works on biological action of NIR were compound and variable (table 6). The most distinct progressive increase was observed in case of sum of all neurophysiological published works with NIR.

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Characteristic of dynamics of sampling fractions (%) of published neurophysiological works with application of different kinds of NIR from the total number of neurophysiological works had other peculiarities (table 7). In all cases the pronounced progressive increase of these sampling fractions of neurophysiological published works with NIR of different kinds and also of them sum took place.

Table 7

Dynamics of the sampling fractions (%) of neurophysiological published works carried out with application of NIR of different kinds in single five-year periods from total number of neurophysiological works during 35-year period

Factors	Indices for different five-year periods						
	1966-70	1971-75	1976-80	1981-85	1986-90	1991-95	1996-2000
1	0.021	0.025	0.046	0.073	0.163	0.233	0.254
2	0.019	0.079	0.142	0.134	0.119	0.106	0.081
3	0.012	0.018	0.033	0.067	0.132	0.154	0.208
4	0.007	0.015	0.026	0.035	0.050	0.059	0.086
5	0.059	0.137	0.248	0.309	0.463	0.551	0.629

Application: as in table 1.

Conclusion

The results of the present bibliometrical investigations makes it possible to analyze quantitative characteristics of neurophysiological published works performed with application of with NIR of different kinds (EMF, MMW, MMF and EF) during 35-year period of later half of XX century (1966-2000 years). The numbers of these published works were found for every observed year. Dynamics of the numbers of published works was studied.

It was established that the total number of published works on neurophysiological effects was 5935. From them 2152 works were made with application of EMF, 1435 of MW, 1649 of MF and 699 of EF. Consequently essential predominance of neurophysiological works with EMF took place.

Positive dynamics of the number of neurophysiological published works with application of all indicated physical factors during 35-year period takes place. But dynamics of the sampling fractions (%) of neu-

rophysiological published works carried out with different kinds of NIR from their sum and from the total number of works on biological action of NIR were complex and unequal. In both cases predominance was observed at the sampling fractions (%) of works with MW in 70-80 years.

However dynamics of sampling fractions (%) of neurophysiological published works with application of all kinds of NIR from the total number of neurophysiological works had gradual pronounced increase.

Unfortunately neurophysiological researches will have further development in XXI century including applied investigations and fundamental science [8, 14].

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S.V. Vyshemyrska

METHODOLOGICAL BASES OF CREATION OF INFORMATION SYSTEMS AND TECHNOLOGIES OF MANAGEMENT OF THE STATE OF HEALTH OF THE STUDENT

Abstract. Methodological approach to process of an individualization of management by a state of health of students is considered. Approach uses the analysis of a wide range of indicators of a state of health with their subsequent generalization for the purpose of formation of an integrated index of estimation of level of health of the student and splitting a great number of students into groups in which various techniques, complexes of exercises and their intensity are applied.

Keywords: health, indicators of a state of health, integrated index of an assessment of level of health.

Introduction. The difficult complex of various factors among which the special place belongs to the academic load connected with intensive cerebration, violation of a mode of work and rest, a hypodynamia, a psychoemotional pressure, stressful situations has impact on a state of health of younger generation. At the same time modern society needs harmoniously developed, competent experts having high level of health and good physical readiness. In this regard in many countries of the world students, as the social group subject to danger of development of many diseases, is allocated in separate group of risk. Management of physical development of students and improvement of their health in the course of physical training represents undoubted interest [1-4].

Work purpose. The assessment of a state of health of each student allows to allocate groups of students which need special approach to occupations by physical culture. For carrying out a practical training on physical training in higher education institutions students taking into account a floor, states of health, physical and sports readiness are distributed in various groups: sports skill, the main, preparatory and special. Chronic diseases cause deterioration of physical development [5]. The purpose of work is consideration of methodological bases of creation of information systems and the technologies providing to the teacher of physical training in higher education institution options of division of students on groups, recommending for each group a complex of exercises and their intensity on the basis of information on a physical state

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and functionality of an organism of a concrete individual.

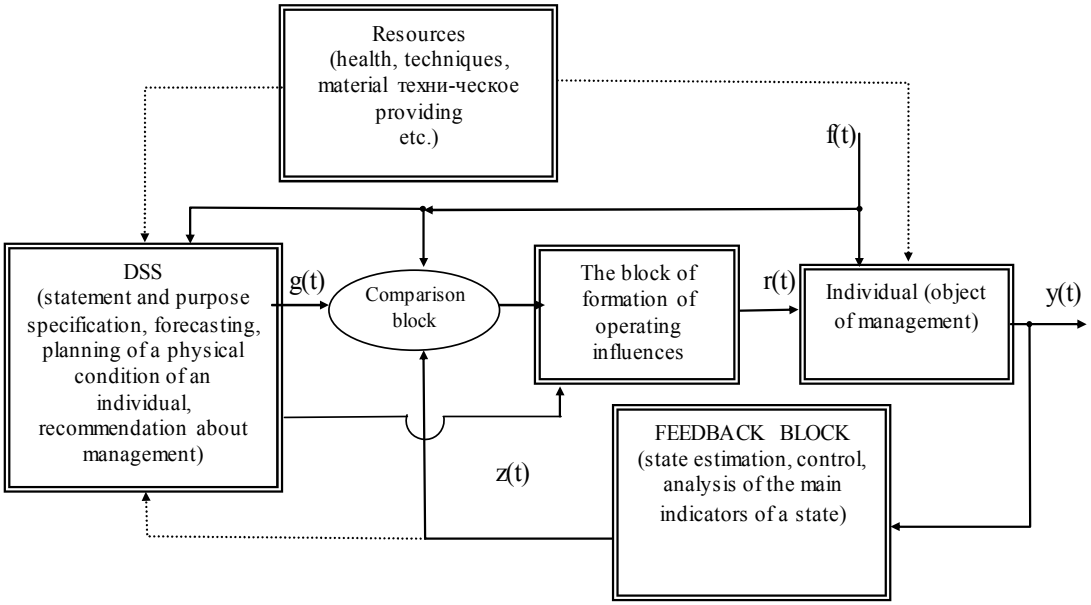
Statement of the main results. Level of a computerization existing today doesn't allow teachers to trace quickly a state of health of students and to accumulate information on each individual. The control system, allowing to automate processing of information is necessary and to operate a state of health of the person. Such system will be capable to develop effective managing directors of influence only in the presence in its structure of a peculiar mechanism of the adaptation providing the adaptation of system to change as object of management, and environment. Formation of model and algorithm of management is offered to be realized by means of the system of support of decision-making (SSDM). SPPR realizes control system adaptation that allows to minimize number of problem situations in which the system isn't able to propose the satisfactory solution. SPPR presents opportunity to the teacher to organize and store individual data of the specific student, to show compliance of its physical condition of the planned trajectory of development and to make the program of correction of health, to carry out necessary imitating modeling, to receive information in a convenient form, etc.

The analysis of opportunities and technology of impact on an individual from positions of the theory of management, allowed to offer the scheme of management of such class of objects (pic. 1). It is known that the control system always has to achieve the objectives of management g (t). In management process control of values of operated parameters and their comparison with the set is exercised. The condition of management is reflected by output indicators at (t) of object of management. The external indignations influencing object, we will designate f (t), to them carry diseases, weather conditions, stresses; r (t) are variable managements, for example, motive exercises; z (t) – variable conditions of object the managements which have taken place preliminary processing in the block of feedback; (t) – mismatch between the actual and desirable state of object of management.

Planning of values of indicators of a condition of a concrete individual has to be real and accepted for it. At development of decisions on management of a condition of the person it is necessary to consider opportunities for their realization and the actions made after decision-making. The major is definition of criteria of adaptive system which can be defined, for example, by means of the function of a penalty considering duration of a deviation of indicators of a condition of object of man-

agement from norm. Except noted features, the system has to give opportunity of estimation of effect from its functioning.

The accounting of the listed requirements to a control system allows to develop the corresponding algorithms of adaptation and mechanisms of management of a physical condition of the person and improvement of its health.



Picture 1 – General scheme of a control system of health of the student

Receiving objective estimates of parameters of health is an important indicator of an assessment of a condition of the person.Such assessment allows to allocate groups which are in a condition of risk, and it in turn plays an important role for diagnostics and prevention of diseases by selection of an individual complex of physical exercises.

It should be noted that rather difficult to measure health level. Therefore for an assessment of health by WHO recommendations indirect indicators such, as physical readiness, adaptation, the psychological and psychophysiological status are used. Given a number of authors, our researches and practical experience testify that among simple and easily available indicators at students the most informative are Robinson, Rufye, Quetelet's indexes, the EVROFIT tests, etc. These indexes are closely interconnected with the size of the maximum consumption of oxygen, and also with other indicators of physical readiness and are used by us for express diagnostics of physical health of students. As such indicators are measured in different units, the separate system is developed for estimation of each indicator in points. Belonging of the student to this or that group and his disease that allows the teacher to

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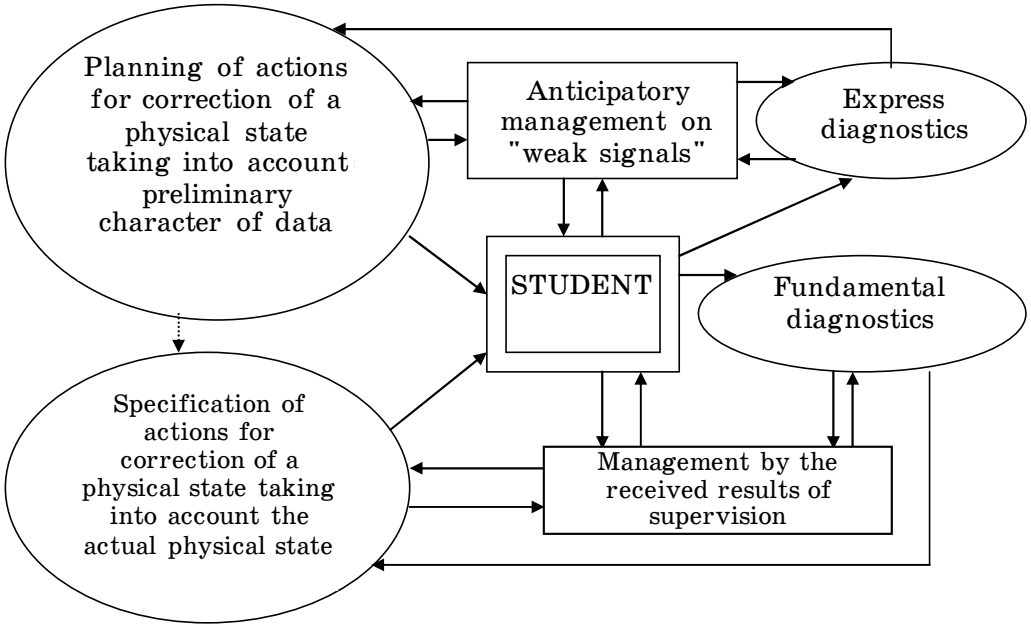
pick up values of parameters of the corresponding tests is thus considered. Following the results of testing the student can get 100 points. Testing is held in two stages: the first – on the speed, force of feet and endurance; the second – on force of hands, dexterity, flexibility. For example, for track and field athletics exercises (run of 100 m, young men) the standard following: 13,2 with – 5 points; 13,9 with – 4; 14,4 with – 3; 14,9 with – 2; 15,5 with – 1 point. Similar scales are created and for other tests.

Students of special medical groups for academic year keep self-checking diaries, hand over educational standards and tests of physical readiness which consider a disease of the student and are modified taking into account specific features of students.

The obtained data allow the teacher of physical culture to select a rational improving and training motive mode that gives the chance to optimize developments of an organism of the student, to level negative influence of a high school mode and the organization of educational process, and also other negatively influencing factors of the environment.

The conducted researches allowed us to offer use of the combined management uniting compensating management on indignations with management by received results of supervision (pic. 2).



Picture 2 – The scheme of the combined management of a functional condition of the student

In this case the operating subsystem beforehand, express diagnostics method, finds an initial stage of influence of destabilizing factors

and tries to eliminate them. Upon termination of a certain period more careful diagnostics of a condition of an organism of an individual which allows to receive objective information is carried out and to make the decision on further operating influences. Such approach to management of a physical condition of an individual allows to minimize both losses from influence of destabilizing factors, and costs of their compensation.

Taking into account diagnostics opportunities in the conditions of a higher educational institution as sources of "weak signals" us testing of motive abilities of students is certain. For the same purpose pulse diagnostics is used.

It is quite easy to enter the offered system of express diagnostics into the information system and to carry out the forecast of a condition of physical health individually for each student and on this basis to plan and choose the relevant activities for their improvement by non-drug means and to select training programs.

Any problem of an assessment of health and diagnostics can be considered as search of display of a formula of a look

$$X^* = \left(x_1^*, x_2^*, \ldots, x_n^*\right) \to d_j \in D = (d_1, d_2, \ldots, d_m) \qquad (1)$$

where – X^* set of parameters of a state investigated;

D – set of possible complexes of exercises.

Difficulties of the solution of problems of an assessment of health are caused by the following reasons:

–for the correct selection of a complex of exercises it is necessary to consider a huge number of parameters of a state surveyed;

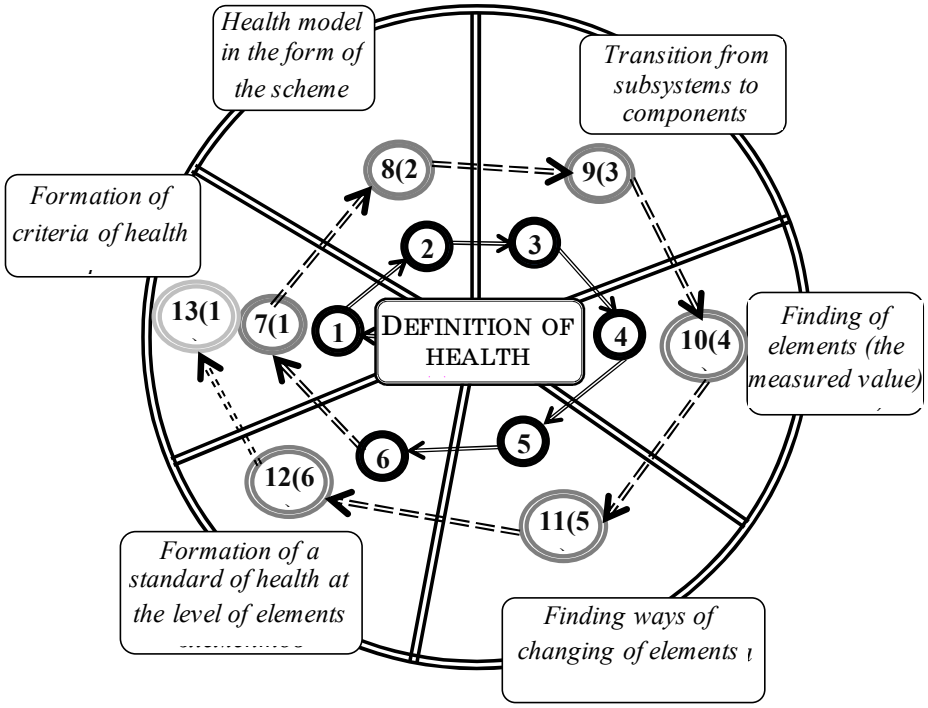
–there are no analytical dependences between parameters of a state surveyed (reasons) and a complex of exercises (consequence).

Complexity of creation of such dependences is defined both a large number of parameters, and their diverse character.They can be as quantitative (age, pressure, pulse, etc.), and qualitative (pain, a state, etc.).In these conditions actual there is a problem of creation of the models used by teachers of physical culture in systems of intellectual support of decision-making.

The spiral model of life cycle of realization of development stages (pic. 3) in which on each spiral turn stages of formation of model of an assessment of health of the student and selection of a complex of physical exercises are realized is put in a basis of development of model of estimation and correction of health of the student. With each subsequent

round quality of development improves and, at last, the acceptable option of model turns out.

The analysis of medical characteristics of an individual allowed when developing model of estimation and correction of health of the student to create four subsystems (pic. 4) which define the main components entering definition of health. Use of the constructed structural model of structure of health of students assumes formation of information and analytical base for adoption of administrative decisions and creation of the relevant system of information support of decision-making.

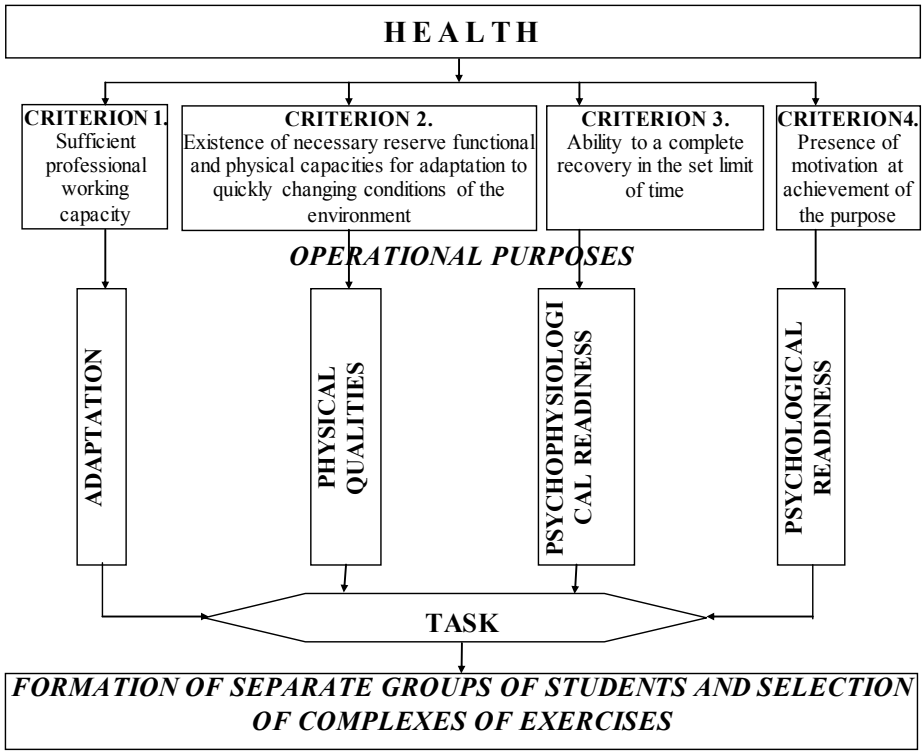


Picture 3 – Development stages of model of an assessment and correction of health of the student

The main form of application of such estimates are physical exercises and natural factors. As organizational bases of correction of health are considered: theoretical preparation, methodical preparation, practical preparation and control. Complex initial his belonging to a certain group allows to define estimates of a condition of the student before occupations. Carrying out classes in the certain program received on the basis of an assessment of a condition of the student, is based on the following principles: continuity; systematic alternation of loadings and rest; gradual increase in loadings and adaptive balance of their dynamics; traditional and nonconventional methods and means of physical im-

provement. Control of efficiency of occupations allows to make recommendations on further grade levels.

Nowadays it isn't present ideal for students of different special groups of integrated indicators of an assessment of health.The problem of selection of students in groups is multicriteria.Characteristics of various components of health belong to selection criteria.Process of selection becomes complicated also that often it occurs in the conditions of incomplete information.It is in advance impossible to call one characteristic according to which selection of an individual will be made.The person making the decision is very frequent, operates with concepts "is healthy", "it is almost healthy", "it is conditionally healthy", "it isn't healthy", etc.Multicriteria on the essence the problem of selection needs development of a method of the decision, allowing to develop effective policy in the matter [7].



Picture 4 – Strategic objectives of improvement of health

Selection of the student in concrete group is offered to be carried out on the basis of expert estimates. During the analysis experts should face such problems, as incompatibility of medical indications of various students, uncertainty of data from a position of their treatment the certain student and the teacher in view of various vision of ultimate goals and so forth. To balance these divergences, rating estimation of health of the student here is used.

To formalization of a problem of selection of the student in concrete group which needs to be solved for all great number of students of higher education institution, it is offered to apply the following scheme of procedure of selection:formation of a set of criteria of estimation of health of a separate individual;data collection about participants of process of selection;development of mathematical models of ranging;formation of an integrated index of estimation of health of the student.Such procedure gives opportunity to calculate a rating of analyzed individuals and to have them in a certain order on a rating scale.

The global criterion of a rating is defined on the basis of primary medical information about health of the student. It is expedient to group primary information in blocks of indicators – set of indicators which define making states of health of the student (for example, "Bone and muscular system", "Cardiovascular system", "A gastrointestinal path", etc.). For each block primary data will be transformed for the purpose of possibility of their comparison, thus rating indicators which for each block of indicators of health of the student then unite in a uniform indicator – an index I turn out. As global criterion on the basis of which the general assessment of health of the student is carried out, the integrated KI index determined by indexes I is applied.

Algorithm of determination of parameters of system of rating estimation of health of students the following.

1. On the basis of available medical indications of analyzed individuals the base of primary indicators of system of rating estimation is formed.Indicators characterizing a state of health are parameters which are based on use of authentic, objective and exact data which are confirmed by the relevant documents.

2. Relative values of indicators (rating indicators) as the relations of primary indicators to the corresponding indicators of comparability of subjects of ranging are defined. Here they paid off, as private from division of each primary indicator into average values following the results of testing of group of analyzed students. It provides compatibility and comparability of indicators.

3. Rationing of indicators and linear convolution in which the model is based on the weighed sum of estimates is made. Rating indicators are normalized for each j-go of an indicator by division of the rating indicators received in item 2 into the sum of the corresponding rating indicators of this indicator on a formula:

$$RN_{ij} = \frac{R_{ij}}{\sum_{i=1}^{M} R_{ij}}, \; i = \overline{1, M} \; ; \; j = \overline{1, N} \qquad (2)$$

4. On the basis of a matrix RN_{ij} of rated rating indicators it is carried out calculations of indexes of each block of indicators of health of students. Indexes pay off as

$$I_{ti} = \frac{1}{m} \sum_{n=1}^{n=b} RN_{ni}^{t}, \qquad (3)$$

where I_{ti} – the t-go index of the block of indicators of health of i-go of the student; RN_{ni}^{t} – n-y rated rating of t-go indicators of the block of indicators of health of i-go of the student; b – number of rated rating indicators in the separate block of indicators of health of the student, $1 \le n \le b$; m – total of rated rating indicators of the certain student.

5. The global criterion of a rating for each student, as the sum of indexes of blocks of indicators of health of each student is defined:

$$KI_i = \sum_{t=1}^{t=d} I_{ti}, \qquad (4)$$

where KI_i – global criterion of a rating of health of i-go of the student; d – number of blocks of indicators of health.

6. Ranging of students on the basis of sizes is carried out and the place of the student corresponding to his level of health is defined. Students with the highest value of global criterion are applicants for transfer in group of sports skill, according to the lowest values – in preparatory medical group.

The considered procedure can be added with application of a hierarchical aglometrichny clustering [8] or introduction of integrated criterion of the entropy type, allowing to estimate a condition of biosystem at any moment:

$$\boldsymbol{IG} = \sum_{j=1}^{n} P_{0j} \mathrm{Ln} \frac{P_{0j}}{P_{1j}}, \qquad (5)$$

where n – quantity of the considered signs characterizing a condition of object;

P_{0j} – the aprioristic probability characterizing "preferable" probability of a condition of object;

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P_{1j} – aposteriorny probability. The probability of that value of a sign X meets "standard". The probability of P_{1j} is calculated on a formula (2):

$$P_{1j} = P(|X - a| < \delta) = 2\Phi(\frac{\delta}{\sigma}) - 1 \quad (6)$$

where - a population mean of a studied sign of x_j;

– the size of deviations of the current x_j value from;

– dispersion of a sign of x_j;

Ф – the standardized function of normal distribution.

In expression (2) probability of P_{0j}=1 as, as a "preferable" condition of object we accept a reference state, at which a deviation =0, therefore:

$$P_{0j} = 1 - \left[2\Phi\left(\frac{0}{\sigma}\right) - 1\right] = 2 - 2\Phi(0) = 2 - 2 * 0{,}5 = 1. \quad (7)$$

Having substituted the received value in a formula (2), we will receive

$$IG = \frac{1}{n}\sum_{j=1}^{n} \ln\frac{1}{P_j}. \quad (8)$$

In this case the integrated indicator of IG allows to estimate degree of a deviation of a condition of biosystem from some (reference) state. So, for example, as a reference state at an assessment of level of physical health the state meeting "physiological standard" was chosen.

Thus, definition of groups of students (sports skill, the main, preparatory and special) for classes in different techniques and physical activities can be carried out according to the offered approaches. If it is necessary, primary data are specified, and procedure is carried out repeatedly.

Conclusions. The researchers conducted by means of complex testing of motive abilities of students, showed that level of physical readiness of students of technical university is low and, as a rule, during training doesn't raise. Introduction in educational process of system of diagnostics of a physical condition of the student and management of this state in the course of classes in physical training will allow to improve indicators of physical readiness of the student and a functional condition of separate systems of its organism, to increase efficiency of diagnostics and adoption of necessary decisions that will promote expe-

ditious correction of a technique of teaching and dispensing of physical activity. Methodological approach to process of an individualization of management by a state of health of students is offered. Approach uses the analysis of a wide range of indicators of a state of health with their subsequent generalization for the purpose of formation of an integrated index of estimation for definition of level of health of the student and splitting a great number of students into groups in which various techniques, complexes of exercises and their intensity are applied. Approach is adapted for opportunities of practical application in the system of support of decision-making providing to the high school teacher of physical training versions of decisions on the organization of work with students and will promote introduction of individual programs of correction of health of students.

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S.V. Vyshemyrska

AUTOMATION OF PRICE FORMING MANAGEMENT AT CHILD'S FOOD INDUSTRY ENTERPRISES

Abstract. The state management system baby food company are presened. The expediency of the use of modern information systems for various tasks in the enterprise are proved. The possibility of using game theory to operational pricing of productsare presented.

Keywords:game theory, pricing, facility management, decision-making.

Introduction. Globalization of economy greatly influences the activity of modern enterprises. Relations with foreign partners became accessible, information and material production lines grew through the borders of states, transport expenses decrease, trade volumes grow, in particular with the countries in Central Europe. The development of adaptation strategy for international market needs becomes actual for many enterprises, that requires active decisions of pricing questions next to an increase of product competitiveness. This problem in proper extent concems to the enterprises of food industry and especially child's food enterprises.

Correct technological development acquire special value in the conditions of food enterprise restructuring, necessity of production products of new types, mastering the specialized production capacities. Effective informative support is necessary for development of corresponding project decisions, which provides leaders, technologist, economists with necessary analytic information as to the perspective and possible variants of the aim achievement. Modern computer technologies substantially simply the process of information accompaniment of technological and organizational decisions making, however existent information systems and technologies difficult in application are costly and often inaccessible to the wide circle of specialists.

Research actuality. The enterprise of child's food is marked with very hard control of products quality, which depends on quality of raw material, terms and terms of storage of raw material and products, correctly calculated compounding, that must take into account all necessities of child's organism on the certain age stage maximum exactly and not deviate from state standards [1, 2]. Expansion of descriptions of

food enterprises products predetermines the origin of wide range of prices. Reducing the price, enterprise will not get permanent advantage, but its increasing has, risks, as competitors have choice: to go back to previous prices or lose the consumers on a benefit of the competitors [5].

Task raising. Development of scientific bases of decision making at a management industrial enterprises is needed for perfection of existent methods of technological processes planning, increase of efficiency of functioning and development of the production-economic systems. The main problem of enterprise management is inconsistency functioning of different chains, which enterprise control system consists of. Creation of effective enterprise control system is predefined by the necessity of multicriterion design of support of acceptance of administrative decisions at planning of productive processes at an enterprise [6]. At the terms of risk and vagueness of design and analysis of situations in pricing for the study of flexible strategies maybe on the base of mathematical vehicle of game theory [7, 8].

It is important to examine the course of processes at an enterprise in dynamic market conditions taking into account that a decision at every next step depends on previous steps. The decision of such tasks will assist in increasing of operative management of technological and economic process at the enterprise of child's food. *The aim of this work* is the consideration of questions of information support in decision making at management pricing at the enterprise of child's food.

Results of researches. The theory of active system which was improved and oriented on the proposed tasks is chosen in this work as development methodology of the information system of decision making support. We divided tasks and corresponding mathematical models into two classes: economic and technological. It is suggested to use complex approach in active systems for task decisions which combines evristic-analytic and probabilistic methods and gives an opportunity to examine tasks from different sides. Possibility using buyers approach within the framework of active systems theory which allowed to get the necessary models of decision making support in particular task was considered next to evristic-analytic methods.

Information system consist of (fig. 1): 1) subsystems' chain which decides technological tasks such as calculation of food packing norm depending on humidity, information for a label, optimization of transportations for supplying with raw material and ready-made products; analysis of organolaptic and physical-chemical indexes of ready-made

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products, automated planning of composite foodstuffs compositions; economic tasks (estimation of investment project risk, situational analysis of the financial state of enterprise, choice of competitive commodity by the method of unclear relation of advantages, active pricing) and others.

Let's consider the game "producer-consumer" for decision of active price forming task. Interests of both sides at the food industry market have antagonistic character. Every player pursues the goals of his price maximization at the expense of the opponents. Enterprises try to maximize their profit owing to higher prices on their products, and the consumer wants to minimize them. In this case the situation of decision making according to a game theory is described with the help of three active elements expressed by sets [11]:

$$\{X, \Theta, F\},$$

where is a set of management object decisions;

$\Theta = \{\theta_1, \theta_2, \ldots, \theta_n\}$ is a set of economic environment status;

$F = f_{kj} = f(x_k, \theta_j)$ – matrix of the evaluation functional values.

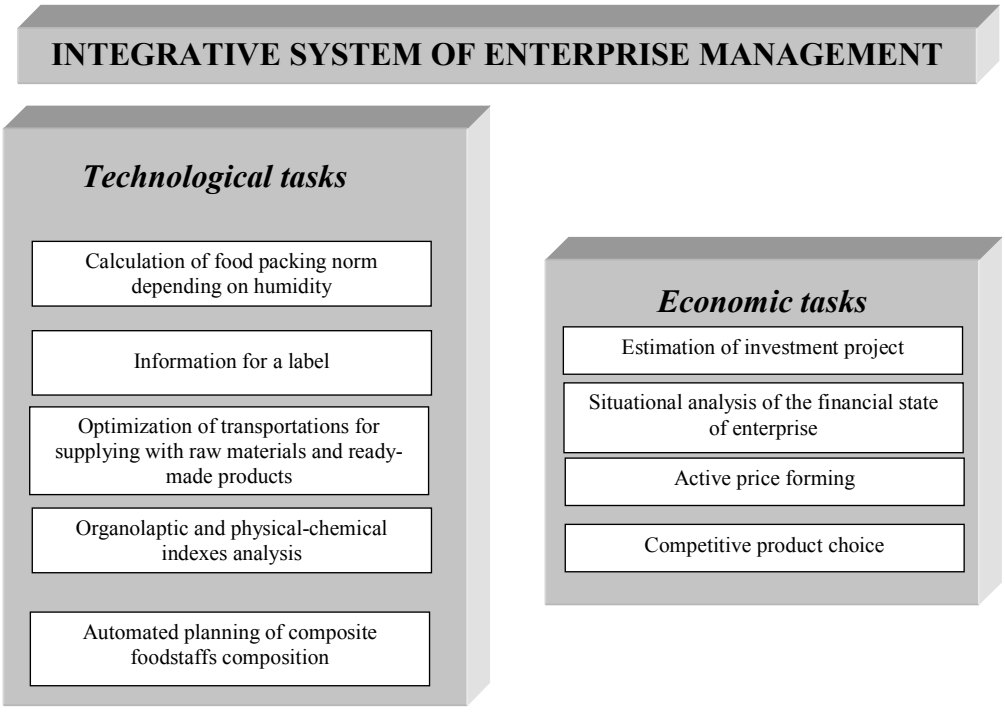

Figure 1 – Integrated control system by an enterprise

Enterprise management must do a correct choice in an antagonism situation. Winning of every pair, which characterizes the relative size of results of actions and depends on such elements, as situations of environment and variant of decision, corresponds to the evaluation func-

tional value to. Proceeding from this form a matrix of the evaluation functional. In detailed form such situation of decision making is set by a matrix the elements of which are f_{kj} are quantitative estimations made decision $x_k \in X$ on condition that an environment is in the state $\theta_j \in \Theta$ [11]. In such matrix a line player has m different strategies (lines), and column – n strategies (columns), thus every number f_{kj} is payment to the line player, if line player chose k strategy, and column j strategy.

The decision of game consists in finding of optimal strategies for every player, that means such strategy which at the permanent repetition of actions gives to the subject maximally possible middle winning. For this purpose use "minimax principle". As elements of matrix F are payments to the line player, then a line player is maximizing in the choice of the line, and column – minimizing in the choice of column. Therefore a line player at first finds a minimum element in every line [12]:

$$\alpha_k = \min_j f_{kj} ,$$

and then elects a line for realization, in which the biggest element from minimum is situated:

$$\alpha = \max_k f_{kj} ,$$

where α is a bottom cost of game.

Like the player of column at first in every column chooses a most value $\beta_j = \max_k f_{kj}$ and optimal strategy chooses after a formula: $\beta = \min_j \beta_j$, where β is an overhead cost of game.

Obviously, that always $\alpha \le \beta$. If $\alpha = \beta$, then a game is called a game with the point of “saddle”. An element for which $f_{kj} = \alpha = \beta$ is named the element of “saddle”. Not every game has a point of “saddle”, however, if a point of “saddle” is, then strategy of players is determined simply.

Wald’s, Gurviz’s and Sevidges criteria suit well in the case characterized by antagonism interests of environment as decision making criteria in the conditions of uncertainty [11].

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The synthesis of the above-mentioned methods allowed to build management pricing frame at the enterprise, basis of which is a sequence of the process stages and decision making moments (fig. 2).

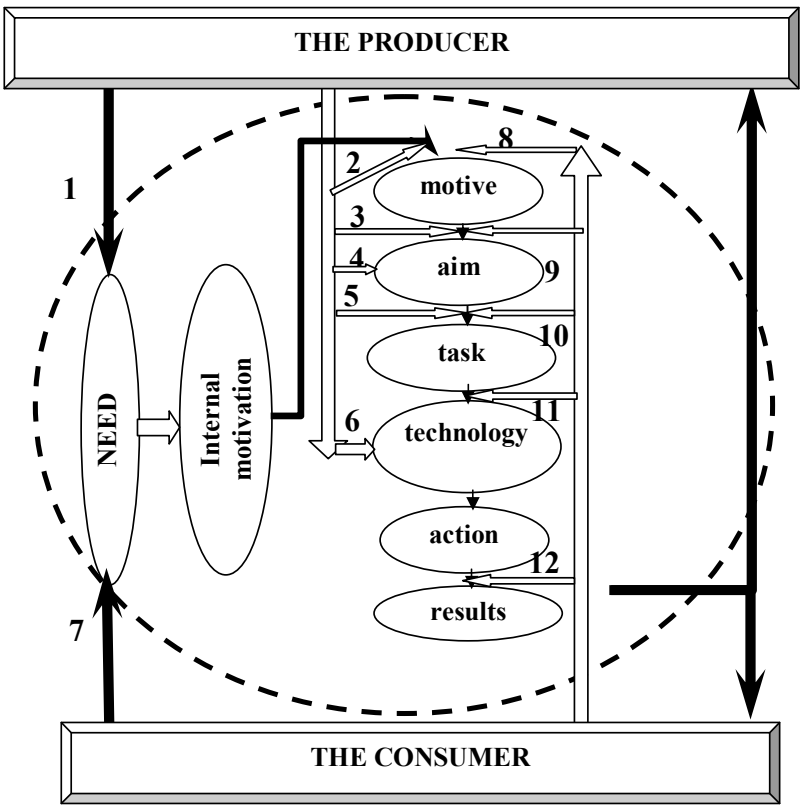

Figure 2 – Management element activity of the active pricing

The approach to be considered was used for the strategy of the active price forming for the "South cannery of child's food", Kherson.

Conclusions. The existent information systems do not answer the requirements of consumers, they are unjustified expensive, does not provide with active estimation of enterprise functioning efficiency, and preparation of recommendations in management decision making. The offered information system consists of separate subsystems, each of which decides the concrete task of enterprise management by economic and technological processes.

Decisions, made by enterprise management in the field of pricing, are the most difficult and responsible, in fact they can not simply worsen financial-economic activity, but also lead the enterprise to bankruptcy. For reasonable decisions making it is expedient to rely on a few variants of prices, calculated for the same products which allows to choose the optimal level of price in a present market situation. The considered mathematical model of the active price forming allows the management to do a right choice in an antagonism game "producer-

consumer" and to make reasonable decisions within the framework of the offered information system of making decision support at the child's food industry enterprise.

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EXPERIMENTAL STUDY OF EFFICIENCY OF SYSTEM-ANALYTICAL RESEARCH BASED ON INDUCTIVE TECHNOLOGIES

Abstract. This article deals with the results of original experiment on comparative analysis of different technology effectiveness of system-information-analytical research (SIAR) in innovative direction. The experiment has been carried out as a Laboratory Practical Master Workshop in the framework of special designed program.

Keywords: analytical research, evaluation criteria, induction, workshop.

Whenever you need to solve the complex problem of system-analytical nature facing researchers arises virtually one and the same problem on the choice of an approach procedure or technology, and hence – and the proper tools to fix it. Today in the system-information-analytical research (SIAR) of search direction [1], as a broad stratum of information technologies of system analysis [2], actively used many methods and technologies, as well as many of their modifications. But among these technologies is the a certain part of them, which is often used in solving practical problems, and therefore are better developed and investigated. Needless probably reject here and powerful role of advertising factor.

Unlike numerical methods of information processing, the efficiency, disadvantages or advantages of which can be objectively established on the results of their solution using the similar tasks on the same data, the comparison innovative technologies of SIAR in solving real problems is extremely difficult or even impossible due to such obvious reasons:

1) the real research require huge expenditures of time and money;

2) the final informational basis sufficient to solve the problem at the beginning of the search is fundamentally unknown;

3) the problem can be solved in different ways and on different elaborated informational bases.

It is advisable in such cases to use the special procedures of modeling the such comparisons. These tools include techniques that in the last century have been called as a business game. It is obviously that these

technologies can be attributed to the methodology of systems analysis as "brain-storming" methods.

The aim of the experiment was to implement the close to the real problems of system-information-analytical researches targeting on specific search problem with variations of different degrees of complexity. The experiment involved the use of compulsory competitive parallel generalized "traditional" technologies (TT SIAR) [1, Fig. 2] and inductive technology (IT SIAR) [3, Fig. 2], as well as an analysis of the experimental results concerning the comparison of the effectiveness of such technologies.

Since the implementation of comprehensive system information-analytical project entails a large quantity of intermediate results that objectively reflect the progress of research, but equally objectively can not be shown completely, in the article below are presented the main components of the present experiment. The main results are concentrated in tables, graphs, charts, etc. without overloading the text with numerous formulas that are exhaustively listed in all necessary references.

1. Essence of experiment and statement of the problem

The experiment aims to obtain objective data to assess the effectiveness of various information technologies of system information-analytical researches of searching type, which depends on the complexity of the investment project . The experiment was carried out according to known procedures of business games of innovation type [4], [5], taking into account, of course, demands of SIAR-technology [1]. As the subject of the experiment has been selected the innovative-investment project in content was close to real applied problems – it was necessary to develop a document, namely: "Innovation-investment project "Industrial fish-breeding farmbased on automated closed water supply system".

Based on the direction, the experiment, as a business game, was carried out as the part of practical training in discipline "Technologies of scientific researches" with magistracy students of 2nd semester of specialty "Automated Control of Technological Processes". Students who have been passed a competitive race, already had a good course design skills as well as sufficient knowledge on the subject and future research merits. In particular, they have already successfully completed the required courses for future research on such subjects as "Technologies of

scientific researches", "Bases of scientific researches", "Fundamentals of Systems Analysis", "Principles of Management, Marketing and Business", "Economics computer aided enterprises in agriculture", "Automated systems of technological processes" and others.

Thus, all performers objectively already had sufficient competence for participation in the experiment, could clearly and briefly to formulate the results of analyzes, to correctly handle with statistical information and execute a clear demand for the necessary "portion" of additional relevant information.

Given the nature of the laboratory experiment some intermediate results had a hue of virtuality, but no more than that it could affect the objectivity of basic and general conclusions. All performers were divided into three groups. The first group carried out of studies by the so-called "one-group" or traditional scheme of SIAR, the other two – exactly twice smaller groups performed the research by inductive technology of SIAR [3] and by the scheme that is described in several previous papers, for example in [7].

The initial information basis is as follows:

1) Complexity of investment projects, W, millions of conventional monetary units (CMU):

1.1) small: $W \leq 10,0$;

1.2) middle: $10,0 < W \leq 25,0$;

1.3) large: $W > 25,0$.

2) 10 days of conventional research equates to 0.5 hours.

3) Tariff salary level members of the research project:

3.1) expert of the analytical group - 2000 CMU/10 conv. days;

3.2) head of Analytical Group - 3000 um.hr.od./10 conv. days;

3.3) a member of the expert committee of the upper level (ECUL): 2000 CMU / Session.

4) Power the farm - 10 000 kg.

2. Results research and their Analysis

In Table 1 are concentrated the all necessary results of the conducted experiment. The number of groups for projects of various category of complexity varied as it is reproduced in the second row of Table 1. The role of the expert committee in business game played the teacher, who had already elaborated the necessary document of real investment project.

Thus, although the number of the expert committee in Table 1 shown virtually, but is approximately the same as it would be required in a real system-analytical projects with similar economic characteristics. Additional information, identical under the form and content, was provided for two groups after going through the each step of the IT SIAR. The group that worked on TT SIAR – upon request, but not more frequently than for two groups who worked on IT SIAR.

Table 1

Comparison of the effectiveness of various technologies SIAR depending on the cost and complexity of the study

No.	Factors, criterion	Category of project complexity / cost, W, million CMU					
		small: W≤10,0		middle: 10,0<W≤25,0		large: W>25,0	
		TT SIAR	IT SIAR	TT SIAR	IT SIAR	TT SIAR	IT SIAR
1	Duration of SIAR, conv. days	60	40	120	60	165	75
2	Staff of SIAR, including manager, of persons	5	5	6	7	8	9
3	Number of steps for IT SIAR	-	4	-	5	-	7
4	Number of completions (quality criterion)	3	0	7	1	9	1
5	Payment for EKUL**) thous. of CMU/ session	-	24,0 (3)	-	50,0 (5)	-	98,0 (7)
6	The budget*) of SIAR, **B**, thous. of CMU	66,0	68,0	156,0	140,0	280,5	240,5
7	Absolute efficiency, **Δ**, thous. of CMU	– 2,0		+ 15,0		+40,0	
8	Relative efficiency, **Δ**, %	– 2,9		+10,7		+16,7	
9	Costs of SIAR in the budget, W, % ***)	1,32	1,36	1,24	1,12	0,85	0,65

*) Counts only the salary of all performers research with EKUL.

**) In parentheses determined the approximate number of experts.

***) Taken into account mid-range of budget, and the "large" – W = 30,0 million CMU.

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According to IT Siad, calculated all system criteria, such as [6]:

- criterion of relevance

$$CR_{rel} = \left(\sum_{i=1}^{m} \sum_{j=1}^{n} (\delta_{ij}^2)_{WE} \right)^{\frac{1}{2}}, \quad (1)$$

- criterion of corelevance

$$CR_{corel} = \left(\sum_{i=1}^{m} \sum_{j=1}^{n} (\delta_{ij}^2)_{WW} \right)^{\frac{1}{2}}, \quad (2)$$

- criterion of information bases balance

$$CR_{inf}(I_b) = \sum_{s=1}^{S} \sum_{k=1}^{K} \delta_{sk} \to \min . \quad (3)$$

Briefly, we recall that criterion of relevance (1) aims at minimizing the difference between the intermediate (final) results of *W (A)* and *W (B)* of two analytical groups A and B and the so-called the benchmark result *E*. Criterion (2) selects the intermediate results of these groups with the smallest divergences. And criterion (3) tracks the "convergence rate" received interim results to the reference outcome, that is, at each step of research discrepancies in queries analytical groups *A* and *B* should be significantly reduced.

Fig. 1 (a) shows the comparative histograms of performances criteria values of both traditional and induction technologies SIAR, depending on the complexity of the project in absolute Δ_{abs} (CMU) and relative Δ_{ac} (%) values that are calculated respectively as:

$$\Delta_{abs} = \mathrm{B}_{TT} - \mathrm{B}_{IT} \text{ and } \Delta_{ac} = \Delta_{abs} / \mathrm{B}_{IT} .$$

Diagrams in Fig. 1 (b) reflect the fate of expenses for research in the total cost of the investment project (in %, see. Table 1).

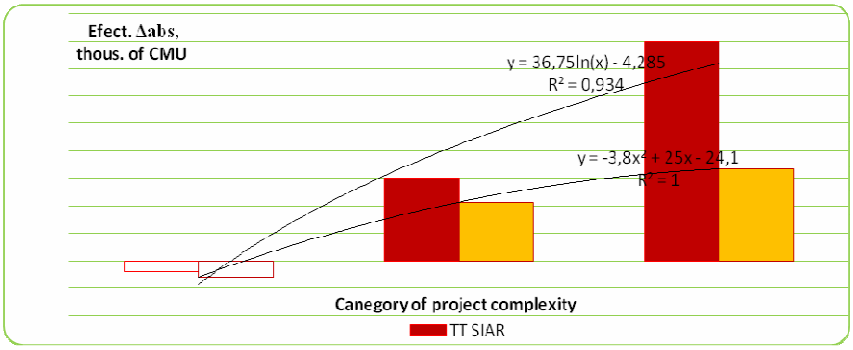
Diagrams in Fig. 1 (c) illustrate the time-cost of implementation of system- information-analytical research to solve the problem for different categories of complexity (cost) of investment.

Fig. 2 displays the dynamic of values changes of all system criteria during the procedure IT SIAR depending on the complexity (investment volume) of the project: (a) – small, (b) – middle, (c) – large.

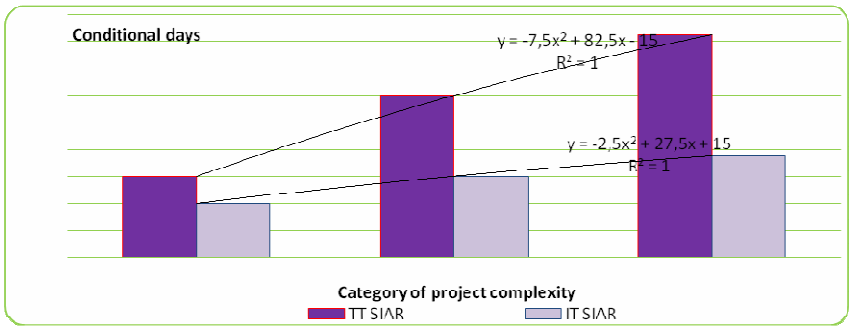
Analysis of the results of experimental researches from Table 1 and from the corresponding graphs are presented in Fig. 1 and Fig. 2, shows that:

1) when performing is not complicated, relatively not expensive and not long-term information-analytical researches the benefits of IT SIAR to the TT SIAR almost absent and, moreover, the former can even concede to traditional technologies, for example, on budget (see Table 1);

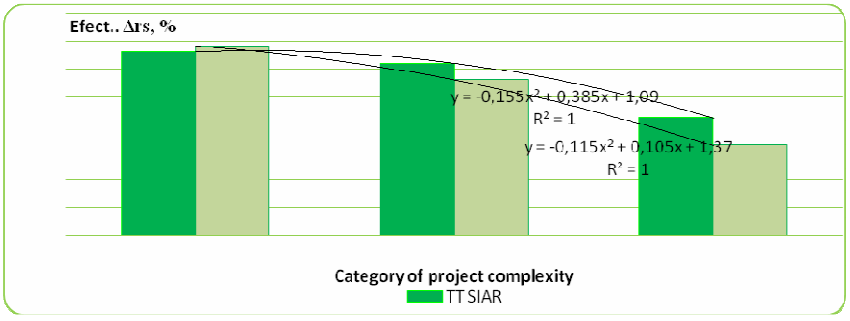
2) obvious advantages of IT SIAR over traditional technologies significantly increase when performing more complex and high-cost information-analytical researches of innovation orientation. For example, with increasing of investment volume in 3 times (in Table 1: 25.0 vs 10.0 mln. CMU) the relative advantage of IT SIAR to TT SIAR, (Δ,%), has increased by more than in 6 times (- 2.9% vs. 16.7%);



(a)



(b)



(c)

Fig. 1. Graphical interpretation of the research results (from Table 1).

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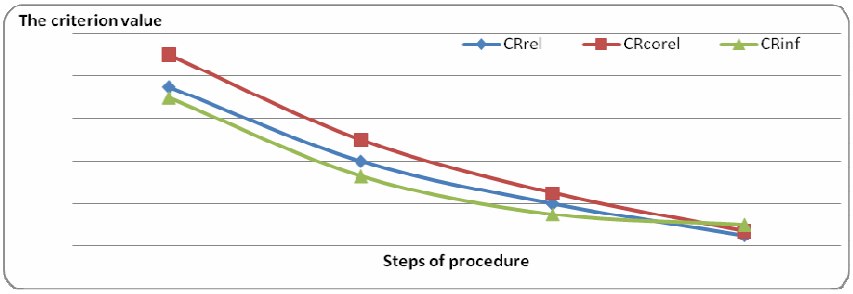
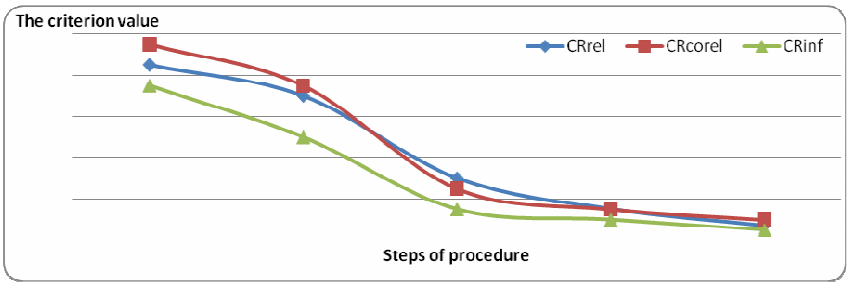
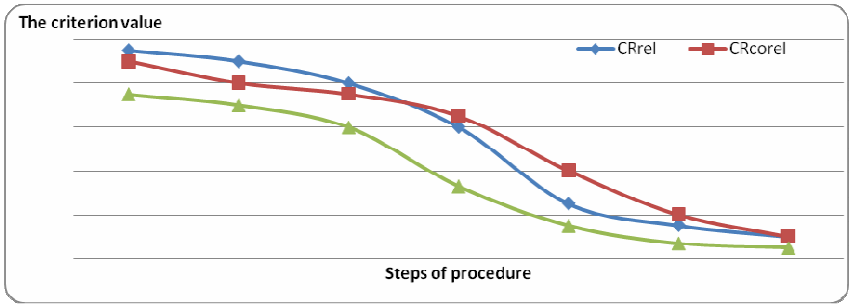
3) the relative value (percentage) of research performance in a total volume of investments in IT SIAR decreases faster than in TT SIAR with increasing complexity (cost) of the project for which searching works are performed.



(a)



(b)



(c)

Fig. 2. Dynamics of changes in the values of criteria (1) - (3) on the steps of inductive procedure SIAR in different variants of the project complexity.

From the analysis performed above one can come the important conclusion that inductive technology of SIAR has significant advantages over traditional procedures when performing the complex and high-cost system information-analysis-researches of innovative direction and, therefore, it is advisable to apply for such class of comprehensive researches. Some of the areas in which the use of IT SIAR it can be most effective, briefly mentioned in [1].

Conclusions

This article describes the results of an experiment designed and conducted to compare the effectiveness of inductive technology with generalized traditional technology of SIAR. Experimental results confirm the conclusion that IT SIAR have advantages over the traditional execution complex and long-term information-analytical research of innivation direction. When solving a simple task inductive technology SIAR have no advantages over the traditional and, moreover, can to concede in efficiency (for example, in the part of their value – Table 1). Therefore, IT SIAR advisable to use to perform the complex and long-term researches.

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KOHONEN NEURAL NETWORK LEARNING IN THE CLUSTERING-CLASSIFICATION TASKS

Abstract. In the paper, combined self-learning and learning method of self-organizing map (SOM-LVQ) is proposed. Such method allows to increase quality of information processing under condition of overlapping classes due to rational choice of learning rate parameter and introducing special procedure of fuzzy choice in the clustering-classification process, which occurs both with external learning signal ("supervised"), and without one ("unsupervised"). As similarity measure of neighborhood function or membership one, cosine structures are used, which allow to provide a high flexibility due to self-learning-learning process and to provide some new useful properties.

Key words: self-organizing map, learning vector quantization, fuzzy clustering, large data set.

Introduction

In Data Mining problems, associated with clustering, classification, fault detection, compression of information and etc., self-organizing maps (SOM) and neural networks of learning vector quantization (LVQ) are widespread. Such neural networks are proposed T. Kohonen [1, 2] and represented in fact by single-layer feedforward architecture, which provides mapping of input space $X \subset R^n$ using some operator F into the output space $Y \subset R^m$.

During operation, each neuron of SOM or LVQ gets information about analyzed input signal. After that, competition mode occurs in single network's layer (also known as the Kohonen layer), and single winner neuron with the maximum output signal is determined. The vector of neuron-winner synaptic weights is most similar in terms of the accepted metric (typically a Euclidean metric) to the input signal. This signal can provide the excitation of nearest "neighbors" of the winner and the reaction suppression of the far dispersed neurons by lateral relations. However, the decision about input vector-pattern membership to one or another class (cluster) is adopted uniquely by the rule of "Winner-Take-All» (WTA). Exactly this uniqueness can lead to the fact that in the case of overlapping classes accuracy of the task solution may be not high due to the fact that the same observation with different levels

of membership (sometimes identical) can belong to some clusters at one time. So, it is reasonable to provide for SOM and LVQ properties and capabilities of fuzzy classification, in addition saved to sequential information processing, i.e. the possibility of operation in on-line mode.

1. Formulation of the problem

Let us consider single-layer neural network with lateral connections containing n receptors and m neurons in the Kohonen layer. Each of the neuron is characterized by it's own synaptic weights $w_j, j = 1,2,...,m$, at the same time during learning process input vector-pattern $x(k)$ is fed on the inputs of all neurons (usually adaptive linear associators) (here $k = 1,2,\ldots$ - either the number of observation in a table "object-properties", or current discrete time for on-line processing mode) and neurons produce the scalar signals on their outputs

$$y_j(k) = w_j^T(k)x(k), \quad j = 1,2,\ldots,m, \tag{1}$$

which depend on current values of synaptic weights vectors $w_j(k)$, that tuned using accepted algorithm for determined input space domain X_j. Similar in the sense of accepted metric input vectors can activate either one and the same neuron w_j, or and its neurons-neighbors, for example, w_j and w_p.

Self-organization procedure is based on the competitive learning approaches (self-learning), and the procedure begins from the initialization of network synaptic weights, selecting usually sufficiently randomly, at that preferably, for each of neurons the normalization condition is performed

$$\left\|x(k)\right\|^2 = x^T(k)x(k) = \left\|w_j(k)\right\|^2 = w_j^T(k)w_j(k) = 1. \tag{2}$$

The goal of this paper is introducing to the self-organizing process the fourth stage – fuzzy inference, which allowed in on-line mode to classify data (in the context of conventional SOM – LVQ architecture), belonging to several clusters at the same time.

2. SOM learning algorithm

The competition process is started to analysis of current pattern $x(k)$, which is fed to all neurons of Kohonen's layer from receptive (zero) layer. For the each neurons the distance is computed in form

$$D(w_j(k), x(k)) = \left\| x(k) - w_j(k) \right\|, \quad (3)$$

at that, if inputs and synaptic weights are normalized accordingly (2) and Euclidian metric is used as distance, than the proximity measure between the vectors $w_j(k)$ and $x(k)$ can be inner product in form

$$w_j^T(k)x(k) = y_j(k) = \cos(w_j(k), x(k)) = \cos\theta_j(k). \quad (4)$$

Using relation (4), we can replace metric (3) to more simple construction, referred to as a measure of similarity [3]

$$\psi(w_j(k), x(k)) = \max\left\{0, \cos(w_j(k), x(k)\right\} = \max\left\{0, \cos\theta_j(k)\right\}. \quad (5)$$

Further we define neuron-winner that is the most similar to the input vector

$$\psi(w_j^*(k), x(k)) = \max_l \psi(w_l(k), x(k)), \quad (6)$$

after that, temporarily omitting the stage of cooperation, tuning of synaptic weights using WTA self-learning rule is realized in form

$$w_j(k+1) = \begin{cases} w_j^*(k) + \eta(k)(x(k) - w_j^*(k)), \text{ if } j-\text{th neuron} \\ \text{won in the competition,} \\ w_j(k) \quad \text{otherwise.} \end{cases} \quad (7)$$

Requirement of monotonic decreasing of the parameter $\eta(k)$ leads to expression in form

$$\eta(k) = r^{-1}(k), \ \eta(k) = \alpha r(k-1) + \left\| x(k) \right\|^2, \ 0 \le \alpha \le 1. \quad (8)$$

One of the SOM features is the presence of cooperation stage in the self-learning process, when neuron-winner defines local domain of topological neighbourhood, in which is trained not only himself, but and his nearest environment, at that neurons, that are more close to winner, adjusts their weights more than a remote. This topological domain is defined by neighborhood function $\varphi(j, p)$, which depends from distance $D(w_j^*(k), w_p(k))$ between winner $w_j^*(k)$ and any of Kohonen's layer neurons $w_p(k)$, $p = 1,2,\ldots,m$ and some parameter σ, which sets its width.

Using of neighborhood functions leads to the self-learning rule in form

$$w_p(k+1) = w_p(k) + \eta(k)\varphi(j, p)(x(k) - w_p(k)), \ p = 1,2,\ldots,m, \quad (9)$$

which minimizes criterion

$$E_p^k = \sum_{\tau=1}^{k} \varphi(j, p) \left\| x(\tau) - w_p \right\|^2 \qquad (10)$$

of produced criterion “Winner Takes More” (WTM) type.

The necessity to maintain of condition (2) leads to the expression in form

$$\begin{cases} w_p(k+1) = \dfrac{w_p(k) + \eta(k)\varphi(j, p)(x(p) - w_p(k))}{\left\| w_p(k) + \eta(k)\varphi(j, p)(x(p) - w_p(k)) \right\|}, \; p = 1, 2, \ldots, m, \\ \eta(k) = r^{-1}(k), \;\; r(k) = \alpha r(k-1) + 1, \; 0 \le \alpha \le 1. \end{cases} \qquad (11)$$

In many real tasks clusters can overlap. In this case vector $x(k)$ with proportional membership level $\cos\theta_j(k)$ belongs *j-th* cluster, and with proportional level $\cos\theta_p(k)$ - to *p*-th one. Synaptic weights, which situated in crosshatched region, don’t have relationship to the pattern $x(k)$ according to (5).

Using similarity measure, we can introduce the membership estimate of pattern $x(k)$ to *j*-th class in form:

$$0 \le \mu_{w_j(k)}(x(k)) = \frac{\psi(w_j(k), x(k))}{\sum_{l=1}^{m} \psi(w_l(k), x(k))} \le 1. \qquad (12)$$

Learning vector quantization neural networks in contrast to self-learning SOM adjust their parameters based on external learning signal (reference signal), which fixed the membership of each pattern $x(k)$ to one or another class. The mean idea of LVQ neural network is the possibility of compact representation of large data sets in the form of restricted prototypes set, or by centroids $w_j(k)$, $j = 1, 2, \ldots, m$, which good enough approximate the initial space X.

For each normalized according to (2) input vector $x(k)$ the neuron-winner is defined, in which the synaptic weights $w_j^*(k)$ correspond to the prototype of the certain class. In other words, winner is neuron with minimal distance to the input vector (9) or, which is the same, with maximal similarity measure (6).

Since the learning is controllable (with supervisor), than membership of the vector $x(k)$ to specific domain X_j of the space X is known,

that allow to consider two typical situation occurring in the trained linear vector quantization:

- the input vector $x(k)$ and neuron-winner $w_j^*(k)$ belong to the same cell of Voronoy [2];

- the input vector $x(k)$ and neuron-winner $w_j^*(k)$ belong to the different cells of Voronoy.

Than corresponding learning LVQ-rule can be written in form:

$$w_j(k+1) = \begin{cases} \dfrac{w_j^*(k) + \eta(k)(x(k) - w_j^*(k))}{\left\| w_j^*(k) + \eta(k)(x(k) - w_j^*(k)) \right\|}, \text{if } x(k) \text{ and } w_j^*(k) \\ \text{belong to the same cell,} \\ \dfrac{w_j^*(k) - \eta(k)(x(k) - w_j^*(k))}{\left\| w_j^*(k) - \eta(k)(x(k) - w_j^*(k)) \right\|}, \text{if } x(k) \text{ and } w_j^*(k) \\ \text{belong to the different cells,} \\ \\ w_j(k) \text{ for neurons, which are not won in instant } k. \end{cases} \quad (13)$$

If the first and third expression of formula (13) are completely identical to WTA – self-learning algorithm, than it should be stayed more details on "push" procedure (second expression of formula (13)).

Let's considered to situation, when neuron $w_j^*(k)$ won in competition, although presented vector-pattern $x(k)$ belongs to the class with centroid $w_p(k)$, and neuron $w_j(k)$ didn't win in competition. Naturally it is necessary to «push» vector $w_j^*(k)$ so, that $x(k)$ was equidistant from $w_j^*(k)$ and from $w_p(k)$.

For that, without comments, we make to the elementary transformation over the expression in vector form:

$$w_j(k+1) = w_j^*(k) - \eta(k)(x(k) - w_j^*(k)), \quad (14)$$

$$x^T(k)w_j(k+1) = x^T(k)w_j^*(k) - \eta(k)\left\|x(k)\right\|^2 - \eta(k)x^T(k)w_j^*(k), \quad (15)$$

$$\cos(w_j(k+1), x(k)) = \cos(w_j^*(k), x(k)) - \eta(k)(1 + \cos(w_j^*(k), x(k))) \quad (16)$$

at that, for providing condition

$$\cos(w_j(k+1), x(k)) = \cos(w_p(k), x(k)) \quad (17)$$

it is necessary to set $\eta(k)$ in form

$$\eta(k) = \frac{\cos(w_j^*(k), x(k)) - \cos(w_p(k), x(k))}{\cos(w_j^*(k), x(k)) + 1} =$$

$$= \frac{\cos(w_j^*(k), x(k)) - \cos(w_p(k), x(k))}{\cos(w_j^*(k), x(k)) + \cos(x(k), x(k))} = \tag{18}$$

$$= \frac{\cos\theta_j(k) - \cos\theta_p(k)}{\cos\theta_j(k) + 1} = \frac{x^T(k)w_j^*(k) - x^T(k)w_p(k)}{x^T(k)w_j^*(k) - x^T(k)x(k)}.$$

3. Compatible learning of SOM and LVQ

In the enough wide class of Data Mining tasks, for example, which are connected to the medical diagnostics, in table «object-properties» for part of the features vectors $x(k)$ the diagnosis is known, and for some one is or ambiguous, or nonunique, or not defined at all. In this case it is possible to tune the synaptic weights with unified architecture with lateral connections using different learning methods. Each of such learning methods initializes according to level of apriori information about membership or not membership $x(k)$ to one or another class.

As a result general learning and self-learning algorithm can be written in form:

$$w_j(k+1) = \begin{cases} \dfrac{w_j^*(k) + \eta(k)(x(k) - w_j^*(k))}{\left\| w_j^*(k) + \eta(k)(x(k) - w_j^*(k)) \right\|}, \\ \delta_L \dfrac{w_j^*(k) - \eta(k)(x(k) - w_j^*(k))}{\left\| w_j^*(k) - \eta(k)(x(k) - w_j^*(k)) \right\|}, \text{if } x(k) \text{ and } w_j^*(k) \\ \text{belong to the different cells,} \\ \delta_L = \begin{cases} 1, & \text{if the network works in supervised model,} \\ 0, & \text{otherwise,} \end{cases} \\ w_j(k) \text{ for neurons, which are not won in instant } k. \end{cases} \tag{19}$$

Conclusion

The combined self-learning procedure for Kohonen neural network is proposed. Such method allows data processing under the overlapping classes condition, when memberships of training data to specific classes can be unknown at all, and have both crisp and fuzzy nature. This method is based on using similarity measure, recurrent optimization and

fuzzy inference and differs with high speed, possibility of operating in on-line mode and simplicity of computational realization.

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A.A. Didyk

BRIEF OVERVIEW OF ANOMALY DETECTION METHODS

Abstract.In the paper problem of anomaly detection and its features in different application domainsare considered, general statement of the problem is performed. Brief overview of existing anomalydetection methods is made, their advantages and disadvantages are discussed. Based on the overview conclusions about given problem domain state of artare made .

Introduction

Anomaly (from Greek – anomalia) – it is a divergence from a norm or a common pattern, abnormality [4]. Within a context of this article, anomalies are considered as the data instances non corresponding to a normal, e.g. taken for a norm, model of a process or a system. Correspondingly, anomaly detection is a process of detecting such anomalous instances in the examined set of data.

The need to detect anomalies exists in a wide range of application domains, such as banking (detection of credit card fraud), computer security (Intrusion Detection System), medicine (detection of data corresponding to any disease in results of medical examinations) and many others [31]. Thus, the topicality of anomaly detection stems from the fact that the presence of anomalies in data correspondsto extremely important and often critical information.

Distinctive features of the anomaly detection problem to be solved in a specific application domainare determined by the following factors [31]:

1. The nature of the analyzed data (attributes of what type describe the instances of data).
2. The availability of a training sample (whether it is possible to use supervised learning or not).
3. The type of anomalies (point, collective, contextual ones).
4. Type of output (designation of the class, to which the analyzed data belong, or anomaly scores of these data).

Statement of the anomaly detection problem

As mentioned above, anomalies areinstancesof data that do not correspond to a normal model of a process or a system. Accordingly, in

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general,the approach to solving of the anomaly detection problem lies in separation of a zone in the future space containing data that correspond to the normal model. Copies of the data that do not fit into the normal zone are anomalous.

Therefore, in general terms the problem of anomaly detection can be considered as a binary classification problem, referring to the category of machine learning problems or learning by precedents. However, traditional classification methods require that the training set of data contains elements of both normal and anomalous class. But as practice shows, the most frequent is the statement of an anomaly detection problem with a training set consisting only of normal data.In this case, the direct use of traditional classification methods is not possible. There are also a number of application domains in which for a number of specific reasons it is impossible to obtain a training setof data. In such cases, the problem of anomalydetection should be regarded as the problem of automatic classification.

We shall consider the general approach to solving of the anomaly detection problem for the case when a training set contains only normal instances of data. At the first stage, a stage of training, it is necessary to obtain a classifying function or a classifier being able to distinguish effectively between normal and anomalousinstances of data that will later be supplied to its input.A learning algorithm is applied which is to detect general dependences, patterns, relationships in a training set of data, which are to be recorded as a model of identified dependences. This model, in fact, approximates a normal model, which is described by the data from a training set. The classifier to be used at the second stage is created based on the model obtained.

In the second stage,a classifier analyzes the data supplied to its input. If the incoming instance of data corresponds to a normal model, it is decided that this instance is normal. In the opposite case, it is considered anomalous.

A brief overview of existing anomalydetectionmethods

The following are the main classes of methods developed for solving the problem of anomaly detection in various application domains.

Methods based on neural networks[11, 13, 30, 32, 8]. The operation of the methods of this class consists of the stages of training and testing of the classifier, i.e. neural network. At the first stage,a neural

network, analyzing training set of data , generates a normal model. At the second stage, each instance of data from a test set is supplied to the input of a neural network. If a network accepts the test data, they are recognized as normal. If the network rejects them, they are recognized as anomalous.

Methods based on Bayesian networks[7, 14, 24, 33].In general, the operation of methods of this class lies in estimating of the posterior probability of belonging of a test data instance to a normal or anomalous class.An object is placed to the class for which the posterior probability is maximal.

Methods based on support vector machine[12, 25, 20, 19]. Methods of this class are based on the construction of the dividing surface to discriminate a zone in feature space, containing the data from a training set. If an instance of data from a test set is within the formed zone, it is recognized as normal, otherwise it is considered anomalous.

Methods based on a system of rules [29, 28, 21].Anomaly detection methods of this class use inference mechanismof a system of rules, which is a normal model. An instance of data from a test set, not covered by any rule of the system, is regarded as anomalous. This class also includes a *method of association rule mining*, which belongs to the category of unsupervised learning. At one of the method stages generating offrequent data subsets is performed. Data subsets with a low occurrence rate are considered anomalous.

Methods of "nearest neighbor"[36, 17, 23, 27].The basis of these anomaly detection methods is the assumption that normal instances of data have in their immediate environment a large number of neighbors, and anomalies are located at a considerable distance from their neighbors.

Methods based on data clustering [35, 5, 22]. Cluster analysis methods are used to split data sets into subsets called clusters, so that instances of data within the same cluster were maximally similar and those in different clusters differed significantly. Anomaly detection methods based on clustering may in turn be divided into three categories.

The methods of the first category suggest that normal instances of data belong to some data clusters, while anomalies do not.

Methods of the second category suggest that normal instances of data are located near the center of mass of the nearest cluster, while anomalies are a significant distance away.

The operational principle of the methods of the third category is based on the hypothesis that normal instances of data belong to large clusters with a high data density, while anomalies either belong to small clusters or to discharged ones.

Statistical methods[1, 34, 15, 6, 18]. The anomaly detection methods of this class are based on the hypothesis that normal instances of data occur in a high probability area of the stochastic model of data, and anomalieson the contrary, in the area of low probability.

Statistical methods build a statistical model to a training data setforits further usage to define whether a new instance of data corresponds to this model or not. Instances that correspond with high probability to the resulting statistical model are considered as normal. Instances belonging to this model with a low probability, are recognized as anomalies. To construct statistical models parametric and nonparametric methods are used. For parametric methods to operate a priori information about the general probability distribution of the original dataset is needed. For nonparametric methods such a priori information is not needed.

Methods based on transformation of the feature space[16, 3, 2, 9, 26, 10]. Methods of this class perform various transformations of feature space aimed, firstly, to reduce its dimension, and secondly, to improve its information capability, i.e. normal and anomalous instances of data in this space will differ substantially from each other and, therefore, anomalousinstances can be easily identified.

For example, the methods of this class are information-theoretic methods and methods of multifractal analysis. Information-theoretic anomaly detection methods analyze the information content of the dataset, which can be characterized by such values as Kolmogorov complexity, entropy, relative entropy, etc. Multifractal analysis methods treat the data set as a multifractal set and analyze changes of characteristics such as fractal dimension, Hurst exponent, Gelder exponent, the Renyi spectrum of fractal dimensions, multifractal spectrum etc. These methods operate on the basis of the hypothesis that

the anomalies in data cause the violation of their information content and their multifractal structure.

In the table 1 some advantages and disadvantages of anomaly detection methods described are given.

Table 1

Advantages and disadvantages of anomaly detection methods

Advantages	**Disadvantages**
Methods based on neural networks, Bayesian networks, support vector machine, a system of rules (methods of multiclass classification)	
- These methods related to the category of classification methods have many implementations, capable to solve the problem of classification with high speed and quality upon condition of availability of training data for both normal and anomalous class. - The advantage of the methods based on Bayesian networks, namely, a naive Bayesian classifier, is a need for a small amount of data required for its training.	- They need a data set for their training, containing data instances of both normal and anomalous class. This condition is difficult to fulfill for a number of application domains. - Algorithms realizing anomaly detection methods based on classification methods designate each test instance of data with a label of the class to which it belongs. This is a disadvantage in cases where upon the conditions of the application domain at the output of the algorithm it is necessary to get the rating of abnormality (anomalous scoring) of each instance of data. - Methods of multi-class classification are hardly acceptable for dynamic application domains in which the concept of "anomalous" is a subject to frequent changes. In this case, it is necessary to update the training set of data and conduct retraining to keep the anomaly detection system up-to-date.

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Methods of “nearest neighbor"	
- Can operate in the mode of both unsupervised learning, in the absence of a training set, and in the mode of semi-supervised learning when only a normal training set is available. - Easily adaptable to the data of different nature through the use of appropriate measures of distance (similarity).	- They are subject to a considerable level of errors of the first and the second type, if the structure of a data set analyzed does not correspond to the base hypothesis, stating that normal instances of data have in their immediate environment a great number of neighbors, and anomalies are located at a considerable distance from their neighbors. - They possess a low level of effectiveness, if a measure of distance (similarity) chosen does not correspond to the nature of the data analyzed. Choosing of suitable measure of distance for data having complex nature, such as graphs, time and other sequences etc. is not a trivial task. - They possess a relatively low computational efficiency, as they require calculating of distance (similarity) for each pair of data instances for training or a test set.
Methods based on data clustering	
- Can operate in the mode of both unsupervised training and in the mode of partial involving of a teacher. - Easily adaptable to the data of different nature through the use of suitable clustering algorithms.	- May produce errors of the first type, if anomalous instances of data are placed to some cluster as the result of an algorithm, the working hypothesis being an assumption that normal instances of data belong to some data clusters, and anomalous ones do not.

	- There is a tendency of occurring of the first type errors, if anomalies in data form relatively large and dense clusters. - They possess a significantly low computational efficiency.
Statistical methods	
- Can operate in the mode of both unsupervised and semi-supervised learning.	- Can effectively solve a problem of anomaly detection only upon the condition of the analyzed data subjecting to a definite probability distribution law, which often is not executed in real application domains, especially for high dimension data sets.
Methods based on transformation of the feature space	
- Can operate in the mode of both unsupervised and semi-supervised learning. - Can be used independently as well as preliminary stage of other anomaly detection methods for dimension decreasing of multivariate data.	- They possess a high level of efficiency only upon condition of justification of an assumption accepted as working hypothesis in these methods, anomalous and normal instances of data being different in the transformed feature space. To a large extent the fulfillment of this condition will depend considerably on the degree of information capabilityof a new feature space obtained by means of transformation of the initial one. - Hardly suitable for the evaluation of the abnormality degree of data instances (anomalous scoring). - Usually possess a low computational efficiency.

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Conclusions

Based on the overview presented above it is possible to draw the following conclusions:

1. The anomaly detection problem is of high and frequently of crucial importance in many real application domains. Therefore, the topicality of research aimed at its solving is beyond question.

2. Taking into consideration a large number of factor values forming the characteristics of anomaly detection problem, its statement in different application domains may differ considerably. It led to emerging of a great quantity of approaches and methods, solving this task with variable success.

3. Currently, there is no a unified method or an approach giving an opportunity to solve this problem successfully in any application domain. Choosing of the method letting to perform anomaly detection maximally effectively in each particular case is not a trivial task, which often turns into attempts to create another new method, surpassing efficiency of existing analogues and free of their disadvantages.

4. All the above-listed forms an important scientific technical problem, solving of which will allow to considerably increase the efficiency of control of systems of different nature.

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SIMULATION PROCESSES AND PERFOMANCE ANALYSIS OF ROUTING PROTOCOL IN CORPORATE NETWORK

Abstract. It is created simulation model of the corporate network MANET with routing protocol based on the GRP. It is illustrated the effectiveness of the protocol for transmission of multimedia traffic.

Key words: protocol, routing, MANET.

Statement of the problem

The most important condition for improving the competitiveness of enterprises is the introduction of modern information technology (IT). To improve the quality of products and services in the business actively implemented corporate information systems. The most important element of the IT infrastructure of corporate networks are designed to ensure interoperability of various applications of information systems. The need to provide quality service modern traffic transmitted over IP-based networks, makes high demands on the efficiency of the transmission of data packets from the sender to the recipient. The task of routing in enterprise networks is solved under the condition that the shortest route, which would ensure transmission of packets in minimum time depends on the network topology, bandwidth and load lines. Network topology changes as a result of the telecommunications system by connecting new nodes and links.

Application of new promising approaches is relevant to the task of routing, for function can improve the quality of corporate network by reducing the complexity of constructing optimal routes.

Analysis of recent research

Today science direction in the field of telecommunication systems with variable topology networks is intensively developed. Such systems are called MANET (Mobile AD hoc Networks) [1]. In [2] proposed a way

to expand the range of scenarios in which the work of routing protocol is effective for transmission of multimedia traffic.

The wording of the purposes of Article (problem)

Objective is to develop a simulation model of a network using MANET routing protocol GRP and study its properties in the transmission of multimedia traffic.

The main part

MANET (Mobile Ad hoc Network) - wireless decentralized networks, that self-organize and consist of mobile devices. Each device can independently move in all directions and as a result often terminate and connect to other mobile nodes. Decentralized wireless networks do not have a permanent structure. Client devices are connected "on the fly", forming a network with random (ad-hoc) topology. Each node of the network tries to send data administrated to other nodes. However, determining which node to forward the data is make dynamically based on network connectivity. Minimal configuration and quick deployment permit to use self-organizing network in emergency situations, during the fight and in other situations where there is no pre-deployed communications infrastructure [3-4].

One of the problems of realization of class MANET networks is to ensure efficiency, safety and reliability of data at the time when randomly changing physical network topology. At the transport level Open Systems Interconnection model (OSI) protocol is based transmission control data - transport mechanism of streaming data from the previous installation of the connection. The protocols of the transport level protocols provide higher levels of work up to the application. Therefore, reliable delivery protocols necessary for the work of many networking applications, such as network file services, messaging services, hypertext transfer services and others that are also used in MANET. However, restrictions imposed by network MANET, do not allow the use of existing Transmission Control Protocol data [5-8], calculated on a stable network topology [9, 10].

Choice of routing protocol makes a significant impact on the efficiency of the network organization and presents an important task for the network administrator. There are factors that significantly influenced on the choice of routing protocol: congestion of network topology and complexity of network reliability requirements, requirements for the protection of the network, compatibility of routing protocols (in combination with other segments of the network), the ability of software routers, qualifications of staff.

IEEE 802.11 - the original standard for wireless local networks based on wireless transmission of data in the range of 2.4 GHz, supports data transfer speeds of up to 1.2 Mbit / s. Standard 802.11b (MANET) increases after the 802.11a data rates up to 11Mbps on the same line 2.4 GHz band [11]. It uses an access method CSMA CA, which helps avoid the problems associated with the sensitivity of the routing path, and method of forming a broadband radio signal DSSS (Direct Sequence Spread Spectrum).

In this paper a special routing protocol GRP (Geometry based Routing Protocol, routing protocol based on the relative position of nodes) is used. It is based on which simulated in the environment of OPNET quantity deleted, copied and created packet delay in the network, routing traffic sent and received. It was analyzed the different metrics to evaluate the performance of the protocol:

- capacity: the total amount of traffic passing through the node;
- the share of delivered packets: the number of received packets divided by the number of sent packets;
- delay: delay from end to end.

In the GRP is required to maintain the routing table before or during the transfer process. In addition, GRP offers a number of advantages over ad-hoc routing. This protocol of forwarding packets allows to adapt to topology changes: the alleged select the next node, if an intermediate, which was used in previous packages are unavailable. This approach does not require the support of the routing table, but informa-

tion about the topology of placing nearest neighbor without routing [12]. Routes can be changed from node to node and from package to package by considering parameters QoS, relating to the transition to the next neighbor or delay and throughput. One of the major drawbacks of this protocol is the difficulty and expense required for maintenance of local distributed database services. However, services cannot be fully shared routing as well as the location of nodes and data is an integral part of distributed traffic information and mobile sensor networks used for control and monitoring applications. For example, the possibility of sending unaddressed and multicast messages to a specific user geographic areas.

The network consists of N mobile nodes randomly distributed in $X * Y$ rectangular area involving wireless communication line. In this paper, the simulated performance units based GRP routing protocol and analyzed using the process model, network model and node (Figure 1-3).

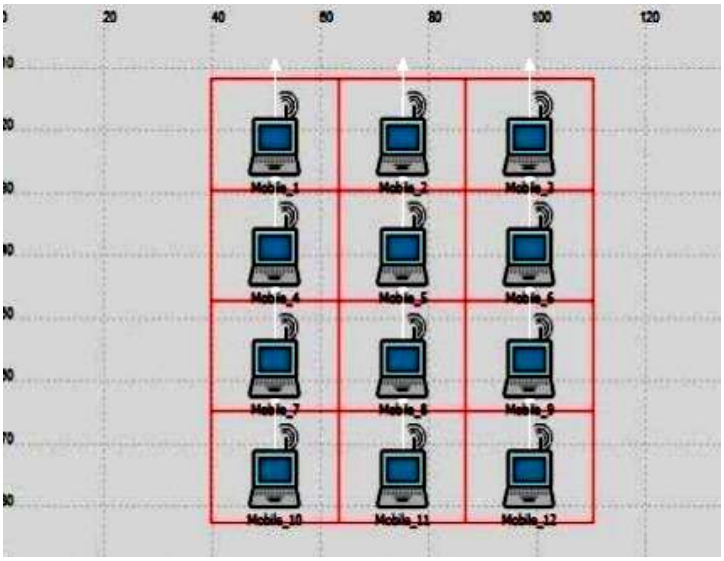

Figure 1 – The model of network

There were used the following parameters in simulation wireless MANET:

- transmission range - 100 m,
- data rate - 11 Mbit / s,
- simulation time - 1 hour
- the number of units - 12

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• field size - 100 x 100 m

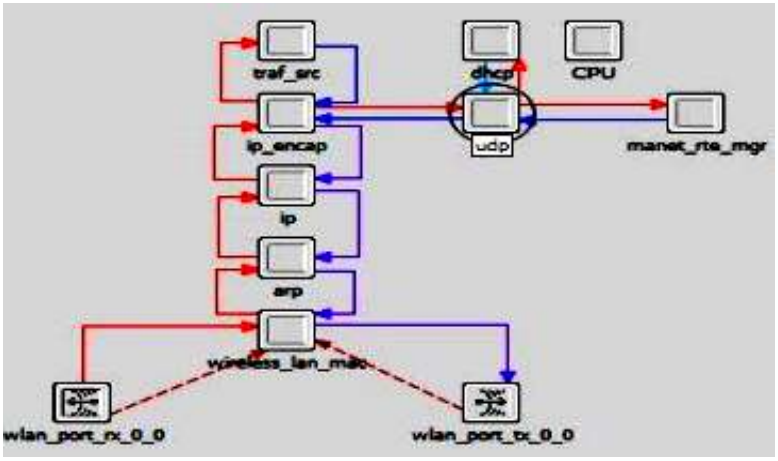

Figure 2 – The model of node

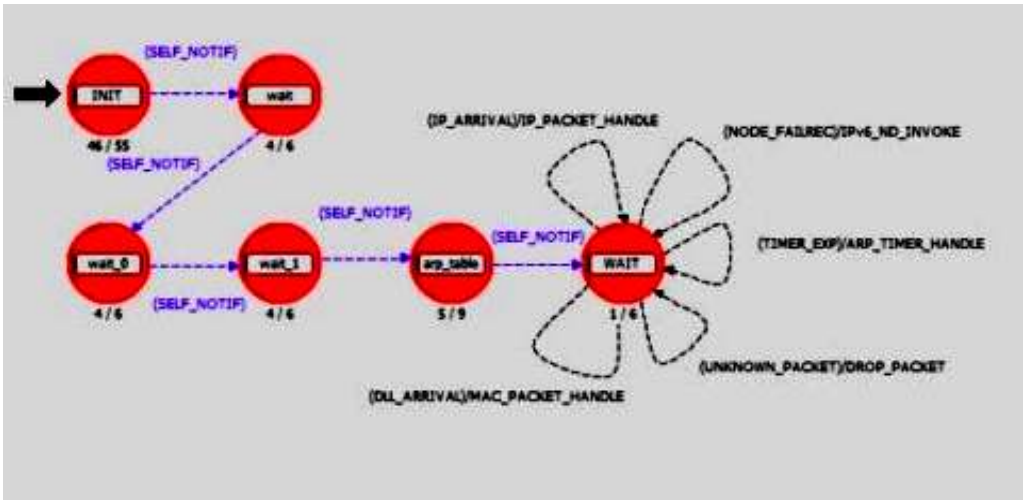

Figure 3 – The model of process of traffic transmission

Figure 4 is represented delay in network by using GRP routing (x-axis - time in minutes, y-axis - the delay in nanoseconds): red tagged received traffic (pkts/sec), and green - traffic sent (pkts/sec).

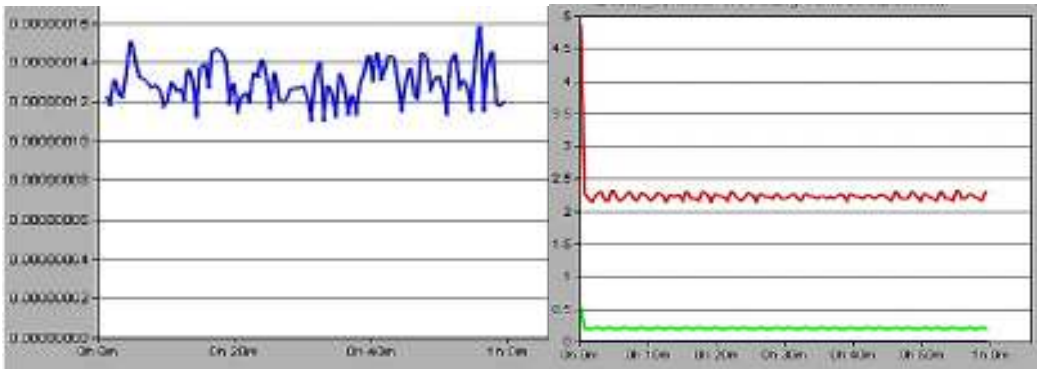

Figure 4:a – End-to-end delay,
b - transmission delay of packet traffic

DC offset in GRP MANET routing traffic in the network is notable (Fig. 5). GRP traffic is measured in packets/second, where the total received traffic represented in bits/second. Posted in MANET traffic is given in bits/second and packets/second. You can see that there is no jump in the transmission of information flow in the network.

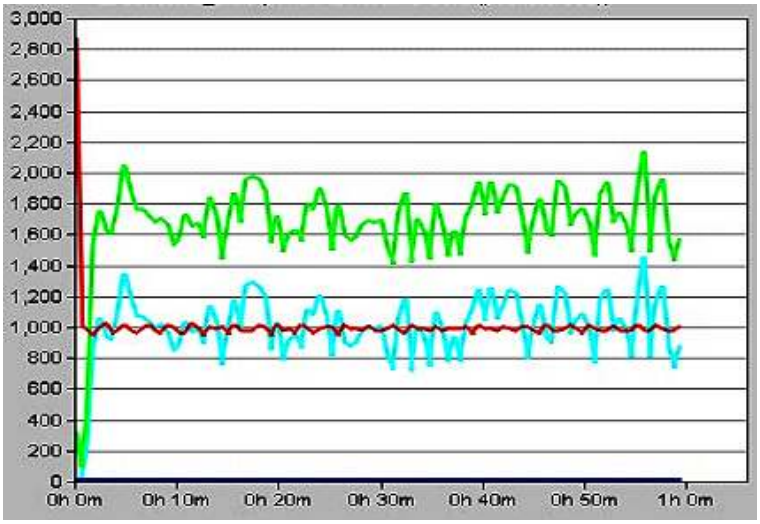

Figure 5 - Input and output traffic based on protocol GRP in MANET network

Conclusions and recommendations for further research

Simulation results demonstrate high performance GRP protocol for total delay sent and received traffic routing input and output traffic bagged, the creation, adoption and destruction packets. Our further research will focus on determining the effective parameters MANET-network, including its bandwidth, using other routing protocols such as DSDV.

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O.V. Kasitskij, P.I. Bidyuk, O.P. Gozhij

APPLICATION OF EXPECTATION MAXIMIZATION THEORY TO SOLVING THE PLOBLEM OF SEPARATION THE MIXTURE OF GAUSSIANS

Abstract.The paper is directed to the study of computationally effective algorithm of modeling and forecastingof optimization type. An analysis is given for the method of Expectation Maximization (EM algorithm), its advantages and disadvantages are considered. A derivation of the algorithm and its detailed description are provided. Some recommendations are given regarding parameter tuning for the algorithm developed. The work highlights a technique for separating the Gaussian mixture using iterative algorithm based on the EM-theory. The results of computing experiments for the EM-algorithm are presented using as example Gaussian mixture separation for two random variables. The conclusions are made regarding the possibilities of application the technique in different conditions.

Keywords. Gaussian mixture, expectation maximizationchoice of the algorithm parameters

Introduction

An expectation maximization theory and respective algorithms (EM algorithm) are used in mathematical statistics for computing of maximum likelihood estimates of probabilistic model parameters in cases when the models depend on some non-measurable variables and incomplete data. The EM algorithm is functioning iteratively and each iteration includes two basic operations. The expectation step (E-step) is used for computing an expected value of a likelihood function using current approximation for non-measurable variables. The maximization step (M-step) is used for selected model parameter estimation that maximize the likelihood computed at the previous step (i.e., at E-step).

The EM algorithm is often used for data clustering, machine learning and in computer vision systems. In the natural language processing systems the Baum-Welch algorithm is often used which is a special case of generalized EM algorithm. Thanks to the possibility of its functioning in conditions of data loss for some variables the EM algorithm also became useful for portfolio risks estimation. Also this theory is used in medical image recognition, especially in the positronemissiontomography and the single-photonemissioncomputer tomography.

For the first time the iterative procedure like EM algorithm, that

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provided a possibility for numerical solution of the likelihood function maximization in the problem of probabilistic distributions separation, was proposed in the study [1]. Later on the idea was exploited in the works [2, 3, 4, 5, 6, 7]. After that it was systematically studied in the work [8]. The name of EM algorithm was proposed in the work [7], devoted to the application of the maximum likelihood approach to the statistical parameter estimation in conditions of incomplete data.

In the study [7] the concept of EM algorithm was proposed as a technique for incomplete data processing. This concept is very handy from methodological point of view and provides a good explanation for an idea of the method. The concept itself has been accepted in further analysis of the algorithm.

As a rule EM algorithms are hired for finding solutions of the problems of two types. To the first type belong statistical problems that are directed towards analysis of incomplete data, i.e. when some statistical data cannot be accessed due to quite definite reasons. Another type of problems create statistical problems that are related to such likelihood functions that do not allow an application of handy analytical research techniques but allow serious simplifications if we can add to the problem additional “non-measurable” (unobserved, hidden, latent) values. Some examples of the second type problems create the problems of image recognition and picture reconstruction. A mathematical core of these applied problems create cluster analysis techniques, classification tasks and the problems of probabilistic mixtures.

The method of sliding separation of the mixtures is at the basis of the proposed lately approach to the study of stochastic structure of chaotic informational streams in complex telecommunication nets [1, 2]. This approach is based on the stochastic model of the telecommunication net in the frames of which it is represented in the form of superposition of some simple series and parallel structures. The principle of maximum entropy in combination with the limit theorems from probability theory are naturally leading to the state that the model generates the mixtures of the gamma type distributions for a parameter that reflects the execution time (processing time) of a request from the net. The parameters of the mixture of gamma distributions generated characterize the stochastic structure of informational streams in the net. To solve the problem of statistical parameter estimation for the mixtures of exponential and

gamma distributions (in the problem of mixture separation) the EM algorithm modification is used.

To study the changes of stochastic structure of informational streams in time the EM algorithm is used in the mode of sliding window. It is very important in the frames of this approach to select an appropriate version of the EM algorithm that provides high execution rate and handy interpreting of the results achieved. This study considers in detail some properties of the EM algorithm and its frequently used modifications and a new approach is proposed directed towards enhancement of precision and stability of the EM algorithm and improvement of interpreting of its functioning results when solving the problem of mixture separation.

The main focus is made here to application of the EM algorithm to the problem of separation of normal mixtures. The problems of studying of such mixtures comprise a kernel for the method of volatility decomposition for financial indexes [3, 4] and turbulent plasma study [5].

In the probability theory the mixture of random variables is defined as a probabilistic distribution of random variable the values of which can be extracted from one of the subordinated probabilistic distributions.

The mixtures of distributions allow to represent complex distributions in the form of simpler ones, and they are used thanks to the fact that they describe well a large number of data samples from real life problems, and thanks to the easy processing of the mixture components.

Consider a set of points in the plain presented in Fig. 1. For simplicity of representation the points are shown in the plain though the theory given below is consistent with the sets of points of any finite dimensionality.

The points in the picture seem to be grouped in clusters. One cluster to the right is noticeably separated from the others. Two more clusters to the left are disposed close to each other and it is not quite clear if it is possible to correctly put a separating line between them.

The problem statement for separating a mixture of distributions

The problem of distribution mixture separation could be defined as follows. Consider a set of N points in D-dimensional space, $x_1, x_2, \ldots, x_N$, and the family F of probabilistic densities in the space ; it is necessary to find a probabilistic density $f(x) \in F$ such, that

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the probability of generating the set of points, $x_1, x_2, ..., x_N$, from this density will be maximum. One of the often used approaches to defining a family of distributions is in providing all of its members with the same mathematical form, and to distinguish them with different values of parameters θ.

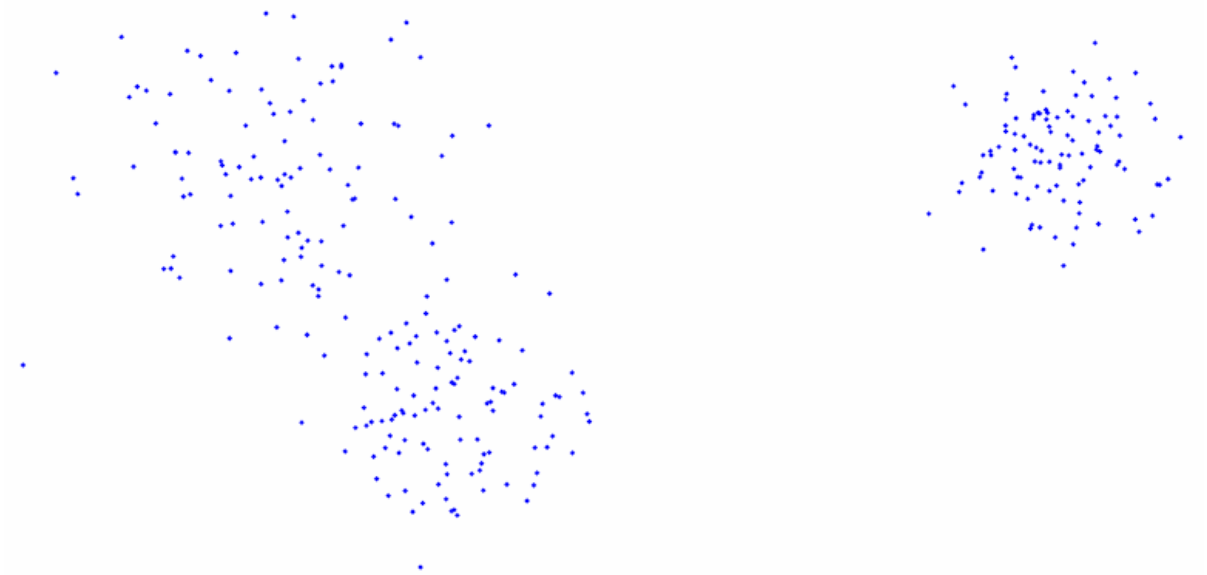

Figure 1 –300 points on the plain

Parametric model

In the following we will be considering the functions, $f(x$, that represent the mixtures of normal distributions:

$$f(x,\theta) = \sum_{k=1}^{K} p_k g(x; m_k \sigma_k),$$

where

$$g(x; m_k \sigma_k) = \frac{1}{(\sqrt{2\pi}\sigma_k)^D} e^{-\frac{1}{2}\left(\frac{\|x-m_k\|}{\sigma_k}\right)^2}$$

is a density of distribution for normal D–dimensional isotopic Gaussian random value; $\theta = (\theta_1, \theta_2, ..., \theta_K) = ((p_1, m_1, \sigma_1), ..., (p_K, m_i)$ is K(D-dimensional vector that includes the probabilities of mixing p_k, mathematical expectations m_k, and standard deviations σ_k, that belong to the K Gaussian distributions.

The density of each distribution, integrated over the space R^D, gives a unity:

$$\int_{R^D} g(x; m_k \sigma_k) dx = 1;$$

Here is a density function of probabilistic distribution, that is why should also integrate to unity:

;

$$\int_{R^D} f(x, \theta) dx = \int_{R^D} \sum;$$

$$\int_{R^D} \sum_{k=1}^{K} p_k g(x; m_k \sigma_k)\, dx = \sum_{k=1}^{K} p_k \int_{R^D};$$

$$\sum_{k=1}^{K} p_k \int_{R^D} g.$$

Thus, sum of the numbers , is a unity. It should also be noticed that the numbers are nonnegative (because the function is nonnegative). This fact explains why the numbers p_k are called the probabilities of mixing.

The generative model

The Gaussian mixtures have been studied well enough in direction of modeling the cluster points: each cluster is assigned to Gaussian with mathematical expectation somewhere in the middle of a cluster, and standard deviation that in some manner describes divergence of a cluster points.

Another view on this modeling problem is that the points in Fig. 1 could be generated through repetitive execution of the two-step procedure given below N times, with one run for each point, x_n:

1. Generate a random value from the set $\{1,2,\ldots,K\}$ in a way that the probability of getting k-th value is p_k. This provides a possibility to select a Gaussian from which will be generated the point x_n.

2. Generate random vector x_n from the k-th Gaussian distribution that is defined by the function $g(x; m_k \sigma_k)$.

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Due to the fact that the defined above family of Gaussian mixtures is parametric, the problem of density estimation could be defined more exactly as a problem of finding the parameter vector θ such, that the mixture function $f(x,\theta)$ is generating the set of points x_n with maximum probability.

It is still necessary to establish what means "with maximum probability". That is, it is necessary to find the function $L($, that measures the likelihood of some definite model with condition that the set of random values is available.

Maximum likelihood approach

Now apply the method of maximum likelihood. The probability of getting the point (value) in a small volume of dx near the point x is equal to the value of $f(x,\theta)dx$. If the points x_n are generated independently, the probability of getting N points will be defined by the expression: $f(x_1,\theta)dx \ldots f(x_N,$. The volume dx is a constant, so it can be ignored in the process of maximizing the probability. Thus, the likelihood function can be written as follows:

.

The parameter estimation problem is formulated in the following way:

$$\hat{\theta} = arg\max_{\theta} L(X;\theta).$$

Determining the probabilities

To continue the problem solving it is useful to introduce the following function:

.

This expression is needed for determining the mixture density. It was assumed in the definition of the likelihood function, $L(X;\theta)$, that generating of the k-th component from generating model is independent on generation of the value x_n from definite component. It follows from this fact that $q(k,n)dx$ is full probability of generating the component k; and the value of x_n is generated by making use of this component.

The problem solution

As it is shown in [6], the problem under consideration has the following solution:

; (1)

((2)

(3)

The first two expressions we can understand on intuitive level as far as and are sample mean and standard deviation, respectively. They are weighted with conditional probabilities that the points (values) were received with the model k. The third equation for mixing the probabilities is not so obvious though not complicated for understanding as far as p_k could be found as a sample mean for conditional probabilities, $p(k|n)$.

An iterative procedure construction

The equations (1) – (3) are closely connected with each other due to the fact that conditions $p(k|n)$ in the right hand side depend on all variables in the left hand side of other equations. Because of this reason the system (1) – (3) cannot be solved directly. However, the EM algorithm provides a possibility to construct an iterative procedure for solving the problem.

The algorithm implementation

To perform the computational experiments the EM algorithm was implemented on the basis of equations (1) – (3). As an estimate for clustering quality the following quadratic criterion was hired:

$$Eps = \frac{1}{K}\sum_{k=1}^{K}(m_k - m_k^*).$$

Consider the quality of separation of two Gaussians with unity standard deviation, $\sigma_1 = \sigma_,$ and with mathematical expectations, $m_1 = -m_2$the sample size was selected at 1000000.

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Table 1

Results of EM algorithm application to mixture separation

№	a	Eps
1	1024	1.36e-6
2	256	3.99e-6
3	64	5.09e-6
4	16	6.82e-7
5	4	1.80e-6
6	1	4.04e-6
7	0.25	6.21e-5

Asitcanbeseenfromthetable 1, thequalityoftheEMalgorithmapplication for separating the mixtures of random variables remains quite acceptable even in the case when the distance between mathematical expectations is less than standard deviation. Now consider in some detail the values of a that are less than 4.

Table 2

EM algorithm application in cases when $a \le 4$

№	a	Eps
1	4	1.37e-6
2	2	1.13e-5
3	1	1.39e-5
4	S	1.13e-4
5	j	1.34e-3
6	1/8	3.66e-3
7	1/16	3.15e-3

The computational results, given in table 2, show that the algorithm used is performing worse when the distance between mathematical expectations of the distributions selected is less than three standard deviations what is easily explained by the three sigma rule. However, even in these cases the quality criterion is changing slowly and the convergence time of the algorithm is growing exponentially.

Conclusions

The paper provides a theoretical analysis of the target sphere of application of the EM theory. The formal problem statement was per-

formed and the method of its solving was considered in necessary detail. The ideas behind the EM theory are presented and a theoretical substantiation for the EM algorithm is given, including the problem of its convergence.

The notion of random variables mixture was introduced and the problem of the mixture separating was formulated. The parametric model for the problem is presented. Also an equivalent generative model is given that was used for constructing the algorithm for generating the Gaussian mixture of appropriate dimensionality. An iterative procedure for solving the problem of Gaussian separation was presented on the basis of EM theory.

The computational experiments performed showed that the EM algorithm was functioning a little worse when the distance between the mathematical expectations of the distributions used was less than three standard deviations what is explained easily by the three sigma rule. At the same time the quality of the distributions separation remained at acceptable level.

In the future research it is necessary to study the possibilities for effective implementation of the EM algorithm based on modern distributed and multiprocessor computer systems.

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UDC 519.7

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APPLICATION OF CLONAL NEGATIVE ALGORITHM TO CANCER CLASSIFICATION WITH DNA-MICROARRAY DATA

Abstract. In the paper, a classification method is proposed. It is based on Combined Clonal Negative Selection Algorithm, which was originally designed for binary classification problems. The accuracy of developed algorithm was tested in an experimental way with the use of microarray data sets. The experiments confirmed that direction of changes introduced in developed algorithm improves its accuracy in comparison to other classification algorithms.

Key words: Negative Selection Algorithm, Clonal Selection Algorithm, Classifier, DNA-Microarray Data, Principal Component Analysis, Wavelet transformation, Feature reduction, Feature selection.

1.Introduction

DNA microarray technology, introduced in 1995–1996, allows the measurement of thousands of gene expression values simultaneously, providing insight into the global gene expression patterns of cells (tissues) being studied [1,2,3]. Despite the need for further technological developments with microarray assays [4], the approach remains powerful for studying the myriad of transcription-related pathways involved in cellular growth, differentiation, and transformation in various organisms. In particular, the ability to measure thousands of gene expressions simultaneously using DNA microarrays has made it possible to investigate genome-wide objective approaches to molecular cancer classification[5].

Empirical microarray data produce large datasets having expression levels of thousands of genes with a very few numbers (upto hundreds) of samples which leads to a problem of “curse of dimensionality”. Due to this high dimension the accuracy of the classifier decreases as it attains the risk of overfitting. As the microarray data contains thousands of genes, hence a large number of genes are not informative for classification because they are either irrelevant or redundant. Hence to derive a subset of informative or discriminative genes from the entire gene set is necessary and a challenging task in microarray data analysis. The purpose of gene selection or dimension reduction is to simplify the

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classifier by retaining small set of relevant genes and to improve the accuracy of the classifier. For this purpose, researchers have applied a number of test statistics or discriminant criteria to find genes that are differentially expressed between the investigated classes [15]

A typical DNA microarray data set in tumor tissue c classification studies consists of expression measurements on thousands of genes over

a small number of known tumor tissue samples ($p \gg N$). However, many

standard statistical methodologies for classification and prediction require more samples than predictors. For example, in regression, $N < p$ leads to an ill-posed problem because the ordinary least squares (OLS) solution is not unique. Another example is Fisher's discriminant analysis, wherethe covariance matrix is singular when $N < p$ [5].

It is challenging to use gene expression data for cancer classification because of the following two special aspects of gene expression data. First, gene expression data are usually very high dimensional. The dimensionality ranges from several thousands to over ten thousands. Second, gene expression data sets usually contain relatively small numbers of samples, e.g., a few tens. If we treat this pattern recognition problem with supervised machine learning approaches, we need to deal with the shortage of training samples and high dimensional input features. Recent approaches to solve this problem include artificial neural networks [7],an evolutionary algorithm[8],nearest shrunken centroids [9],and a graphical method [10].

A number of recent publications report on the successful application of support vector machines (SVMs) to the classification of high-dimensional microarray data [11-13].

Therefore, high-dimensional microarray data present a major challenge for these classifiers. However, the algorithms of Artificial Immune System (AIS) have not been widely explored for cancer classification with microarray data. Yet there exist in literature only very few studies in which AIS were applied to microarray classification. Therefore, this study introduced an artificial immune system approach for

cancer detection based on negative selection algorithm (NSA) and Clonal Selection Algorithm (CSA) named Clonal Negative Algorithm (HCNA).

2. Materials and methods

In this study, the microarray data classification was performed in three stages: dimensionality reduction using the Principal Component analysis, Feature extraction using the discrete wavelet transform and classification using hybrid clonal negative algorithm (HCNA).

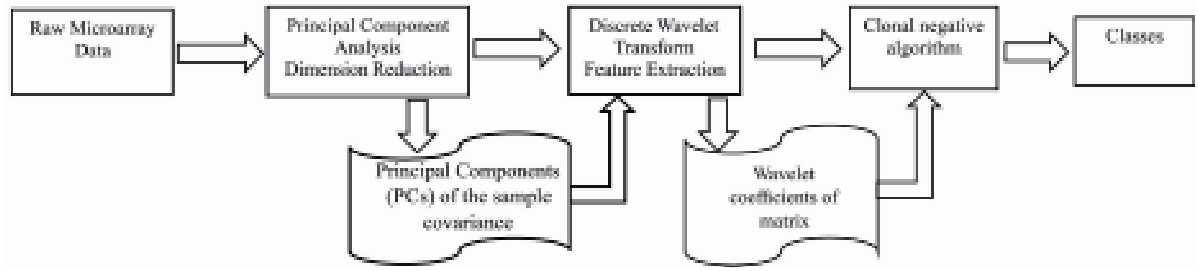

Figure 1 – Structure of the HCNA Classifier

2.1 Dataset

Microarray datasets take the form of expression data matrix where rows represent the genes and columns represent the samples. Each cell in this data matrix is a gene expression value which expresses the gene intensity in the corresponding sample. The expression data matrix will be finally dealt with in the form X_{ij} where; $0 < i \le n_g, 0 < j \le n_s$ and n_s, n_g are the total number of genes, total number of samples respectively as in figure 2. Each expression data matrix will be further divided into two matrices; training data matrix Y_{ik} and test data matrix Z_{ip} where k, p are the number of samples used in the training process, test process respectively and $p + k = n_s$. The training data matrix will be used to train all the used classifiers and their performance will be evaluated using the test data matrix only [16].

$$\mathbf{x}_{ij} = \begin{pmatrix} \mathbf{x}_{11} & \mathbf{x}_{12} & \cdots & \mathbf{x}_{1n_s} \\ \mathbf{x}_{21} & \mathbf{x}_{22} & & \mathbf{x}_{2n_s} \\ & & & \\ \mathbf{x}_{n_g 1} & & & \mathbf{x}_{n_g n_s} \end{pmatrix}$$

Figure 2 – Expression data matrix

In this section, the cancer gene expression data sets used for the study are described. These datasets are also summarized below.

ALL/AML Leukemia Dataset. The dataset consists of two distinctive acute leukemias, namely AML and ALL bone marrow samples with 7129 probes from 6817 human genes. The training dataset consists of 3B8 samples (27 ALL and 11 AML) and the test dataset consists of 34 samples (20 ALL and 14 AML).

Colon Dataset. The dataset consists of 62 samples from 2000 genes. The training dataset consists of 42 samples where (30 class1, 12 class2) and the test data set consists of 20 samples (10 class1, 10 class2).

Prostate cancer. Prostate cancer data contains training set of 52 prostate tumor samples and 50 nontumor (labeled as "Normal") prostate samples with 12 600 genes. An independent set of test samples is also prepared, which is from a different experiment. The test set has 25 tumor and 9 normal samples.

2.2 Dimensionality reduction using the Principal Component analysis

Principal component analysis (PCA) is used to search new abstract orthogonal principal components (eigenvectors) which explain most of the data variation in a new coordinate system [17]. Classical PCA is based on the decomposition of a covariance/ correlation matrix (Geladi and Kowalski (1986)) by eigenvalue (spectral) decomposition (EVD) or by the decomposition of real data matrixes using SVD [18].

PCA is a multivariate procedure aimed at reducing the dimensionality of multivariate data while accounting for as much of the variation in the original data set as possible.

This technique is especially useful when the variables within the data set are highly correlated and when there is a higher than normal ratio of explanatory variables to the number of observation. Principal components seeks to transform the original variable to a new set of variables that are (1) linear combinations of the variables in the data set, (2) uncorrelated with each other, and (3) ordered according to the amount of variation of the original variables that they explain [17,19]

PCA is a well-known method of dimension reduction [20]. The basic idea of PCA is to reduce the dimensionality of a data set, while retaining as much as possible the variation present in the original predictor variables. This is achieved by transforming the p original variables $X = [x_1, x_2, \ldots, x_p]$ to a new set of K predictor variables, $T[t_1, t_2, \ldots, t_K]$, which are linear combinations of the original variables. In mathematical terms,

PCA sequentially maximizes the variance of a linear combination of the original predictor variables,

$$u_K = \arg\max_{u'u} \mathrm{Var}(Xu) \quad (1)$$

subject to the constraint $u_i' S_X u_j = 0$, for all $1 \le i \le j$. The orthogonal constraint ensures that the linear combinations are uncorrelated, i.e. $\mathrm{Cov}(Xu_i, Xu_j) = 0, i \ne j$. These linear combinations

$$t_i = Xu_i \quad (2)$$

are known as the principal components (PCs) [21]. Geometrically, these linear combinations represent the selection of a new coordinate system obtained by rotating the original system. The new axes represent the directions with maximum variability and are ordered in terms of the amount of variation of the original data they account for. The first PC accounts for as much of the variability as possible, and each succeeding component accounts for as much of the remaining variability as possible. Computation of the principal components reduces to the solution of an eigenvalue-eigenvector problem. The projection vectors (or called the weighting vectors) u can be obtained by eigenvalue decomposition on the covariance matrix S_X,

$$S_X u_i = \lambda_i u_i \quad (3)$$

where λ_i is the *i*-th eigenvalue in the descending order for $i = 1, \ldots, K$, and u_i is the corresponding eigenvector. The eigenvalue λ_i measures the variance of the *i*-th PC and the eigenvector u_i provides the weights (loadings) for the linear transformation (projection). The maximum number of components K is determined by the number of nonzero eigenvalues, which is the rank of S_X, and $K \le \min(n, p)$. The computational cost of PCA, determined by the number of original predictor variables p and the number of samples n, is in the order of $\min(np^2 + p^3, pn^2 + n^3)$. In other words, the cost is $O(pn^2 + n^3)$ when $p > n$ [22].

2.3 Discrete wavelet transform-feature extraction

Suppose that the vector $\bar{\xi}_1$ has a sequence consisting of the 2^n points, for some integer $n > 0$. This sequence can be identified with the

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next function in the space V^n of piecewise constant functions at equidistant intervals of length $1/2^n$:

$$f(t) = x_1\phi_{n,0}(t) + \ldots + x_{2^n}\phi_{n,2^n-1}(t) \quad (4)$$

where $\phi(t)$- scaling functions of space V^n. The first step in calculating the wavelet decomposition of the sequence $\{x_1, x_2, \ldots, x_{2^n}\}$ is the decomposition of $f(t)$ on the alternative basis of the space V^n, which constitute half of the wavelets $\psi(t)$:

$$f(t) = A_{n-1,0}\phi_{n-1,0}(t) + \ldots + A_{n-1,2^{n-1}-1}\phi_{n-1,2^{n-1}-1}(t) + D_{n-1,0}\psi_{n-1,0}(t) + \ldots + D_{n-1,2^{n-1}-1}\psi_{n-1,2^{n-1}-1}(t) \quad (5)$$

where A - approximation coefficients, defining coarse low-frequency component of the original signal, D - detail coefficients, defining the high-frequency component of the original signal. The next step of the conversion process is the use of the same basic conversion the members of (2), containing the approximation coefficients. Detail coefficients at the same time remain unchanged. Block diagram of the wavelet decomposition is presented in Figure 3.:

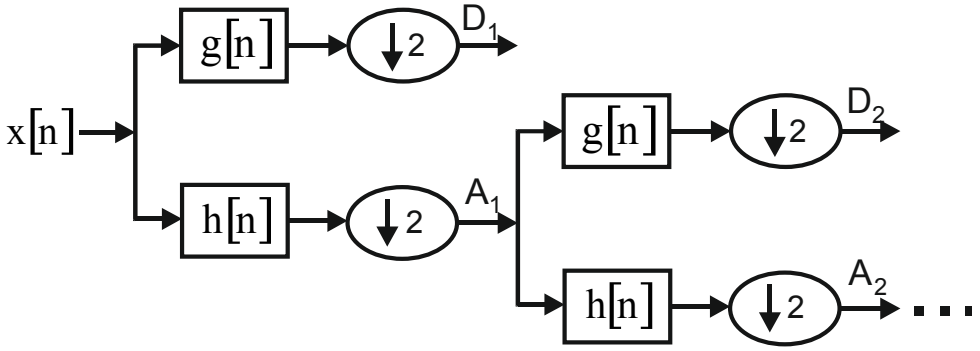

Figure 3 – Structural diagram of a discrete wavelet decomposition of the signal; $g[n]$ - high frequency transmit filter, $h[n]$- low frequency filter transmitting.

The Data used in this research were analyzed into the details D1-D2 and one final approximation, A2. Our previous studies [23] have shown that the the smoothing feature of the Daubechies wavelet of order 13 (db13) made it more suitable to detect changes of the microarray data. Hence in our research, we used the db13 to compute the wavelet coefficients of the microarray data.

For receiving approximation and detail coefficients using orthogonally and normalization the property. In the basic functions, all scaling functions, as well as the wavelet functions are orthogonal to each other, in addition, each $\psi(t)$ and each $\phi(t)$ are normal. Multiplying both parts of (2) on $\phi_{n-1,j}(t)$ and we will integrate on t from 0 to 1. As a result, we will receive

$$\int_0^1 f(t)\phi_{n-1,j}(t)dt = A_{n-1,j} \tag{6}$$

Now we substitute the right-hand side of equation (1) instead of f (t) in (3). If $j = 0$ at the left side of (3) will be equal to:

$$\int_0^{1/2^n} x_1\sqrt{2^n}\sqrt{2^{n-1}}dt + \int_{1/2^n}^{2/2^n} x_2\sqrt{2^n}\sqrt{2^{n-1}}dt = (x_1 + x_2)\left(\frac{1}{\sqrt{2}}\right)2^2\left(\frac{1}{2^n}\right) = \frac{x_1 + x_2}{\sqrt{2}} \tag{7}$$

Combining (3) and (4) at $j = 0$, we will receive:

$$A_{n-1,0} = \frac{x_1 + x_2}{\sqrt{2}} \tag{8}$$

The remaining coefficients $a_{n-1,j}, j = 0,\ldots,2^{n-1} - 1$ are computed in the same way:

$$A_{n-1,j} = \frac{x_{2j+1} + x_{2j+2}}{\sqrt{2}} \tag{9}$$

Similarly, using the properties of orthogonally and normalization of the functions $\psi_{n-1,j}$, we can calculate the detailing coefficients $D_{n-1,j}$ using the following formula:

$$D_{n-1,j} = \frac{x_{2j+1} - x_{2j+2}}{\sqrt{2}} \tag{10}$$

Ultimately, we obtain the matrix approximation and detail coefficients at a given level of decomposition.

The computed discrete wavelet coefficients provide a compact representation. In order to further decrease the dimensionality of the extracted feature vector, statistics over the set of the wavelet coefficients

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are used. The following statistical features were used to represent the time-frequency distribution of the microarray data:

- Maximum of the wavelet coefficients in each subband
- Minimum of the wavelet coefficients in each subband
- Mean of the wavelet coefficients in each sub-band
- Standard deviation of the wavelet coefficients in each sub-band.

2.4 Artificial immune algorithms

In the 1990s, Artificial Immune System (AIS) emerged as a new computational research filed inspired by simulation of biological behavior of Natural Immune System (NIS). The NIS is a very complex biological network with rapid and effective mechanisms for defending the body against a specific foreign body material or pathogenic material called antigen .

The Artificial Immune Systems, as defined by de Castro and Timmis [24] are: "Adaptive systems inspired by theoretical immunology and observed immune functions, principles and models, which are applied to problem solving". However AIS are one of many types of algorithms inspired by biological systems, such as neural networks, evolutionary algorithms and swarm intelligence. There are many different types of algorithms within AIS and research to date has focused primarily on the theories of immune networks, clonal selection and negative selection. These theories have been abstracted into various algorithms and applied to a wide variety of application areas such as anomaly detection, pattern recognition, learning and robotics [25].

Negative selection algorithm. The negative selection of T-cells is responsible for eliminating the T-cells whose receptors are capable of binding with self-peptides presented by self-MHC molecules. This process guarantees that the T-cells that leave the thymus do not recognize any self-cell or molecule. Forrest et al. [26] proposed a change detection algorithm inspired by the negative selection of T-cells within the thymus. This procedure was named as negative selection algorithm and was originally applied in computational security. A single type of immune cell was modelled: T-cells were represented as bit strings of length L. The negative selection algorithm of Forrest and collaborators is simple [26]. Given a set of self-peptides, named self-set S, the T-cell receptors will have to be tested for their capability of binding the self-peptides. If

a T-cell recognizes a self-peptide – it is discarded, else it is selected as an immune-competent cell and enters the available repertoire **A**.

The idea of negative selection algorithm is to generate a set of detectors in a complementary set of **N** and then to use these detectors for binary classification as "Self" or "Non-Self". Formally, the negative selection algorithm can be represented as **[27-28]**:

$$\mathrm{NegA\,lg} = \left(\Sigma^{\mathrm{L}}, \mathrm{L}, \mathrm{S}, \mathrm{N}, \mathrm{r}, \mathrm{n}, \mathrm{s}, \mathrm{pr}\right) \qquad (11)$$

where Σ^{L} denotes shape-space; *L* is receptor length; **S** is "Self" detector set; **N** is "Non-Self" detector set; *r* denotes cross-reactive threshold; *n* is total number of appointed detectors; *s* is detector set size; *pr* denotes rule matching rows in adjacent positions.

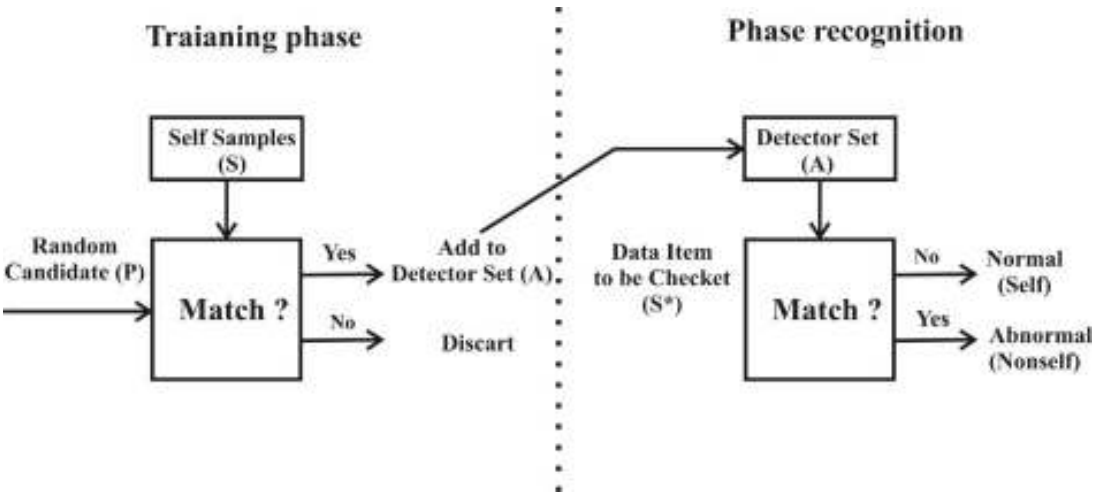

Figure 4 – Negative selection algorithm **[29]**

The negative selection algorithm can be summarized as follows:

- *Initialization:* randomly generate strings and place them in a set **P** of immature T-cells, assuming all the molecules (receptors and self-peptides) are represented as binary strings of the same length ***L***.
- *Affinity evaluation:* determine the affinity of all T-cells in V with all elements of the self set **S**.
- *Generation of the available repertoire:* if the affinity of an immature T –cell with at least one self-peptide is greater than or equal to a give cross reactive threshold, then the T-cell recognizes this self-peptide and has to be eliminated (negative selection); else the T-cell is introduced into the available repertoire **A**.

The process of generating the available repertoire in the negative selection algorithm was termed learning phase. The algorithm is also composed of a monitoring phase. In the monitoring phase, a set $\mathbf{S}^{*}$of

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protected strings is matched against the elements of the available repertoire A. The set **S*** might be the own set **S**, a completely new set, or composed of elements of **S**. If recognition occurs, then a non-self pattern (string) is detected.

It is well known, that the algorithm of negative selection (NS) has the some restrictions and limitations [29]. When it is not appropriate, for example, the number of self samples is small and sparse.

Some limitations of the binary-string representation in NS algorithms are as follows:

- binary matching rules are not able to capture the semantics of some complex self/non-self spaces,
- it is not easy to extract meaningful domain knowledge,
- in some cases a large number of detectors are needed to guarantee better coverage (detection rate),
- it is difficult to integrate the NS algorithm with other immune algorithms,
- the crisp boundary of “self” and “non-self” may be very hard to define.

In real-valued representation the detectors are represented by hyper-shapes in n-dimensional space. The algorithms use geometrical spaces and use heuristics to distribute detectors in the non-self space.

Some limitations of the real-valued representation in NS algorithms are:

- the issue of holes in some geometrical shapes, and may need multi-shaped detectors,
- curse of dimensionality,
- the estimation of coverage,
- the selection of distance measure.

During our experiments it has been established that generation of set of detectors in at training phase occurs casually owing to what it is in advance impossible to define is minimum necessary quantity of detectors which will provide the maximum quality of recognition. The increase in quantity of detectors conducts to delay of a phase of recognition, and its reduction – to deterioration of work of algorithm since the probability of formation of the "cavities" which are areas in space of “Non-self” which are not distinguished by any of detectors increases.

Thus, a problem of the given research is working out of an advanced method of generation of the detectors, capable to adaptive selection of their options, quantity and an arrangement.

Clonal selection algorithm. Today the algorithm CLONALG exists in two forms [24]: (1) for optimization problems solving, and (2) for solving problems of classification and pattern recognition. Basic clonal selection algorithm [24]., named CLONALG, works as in Fig. 5

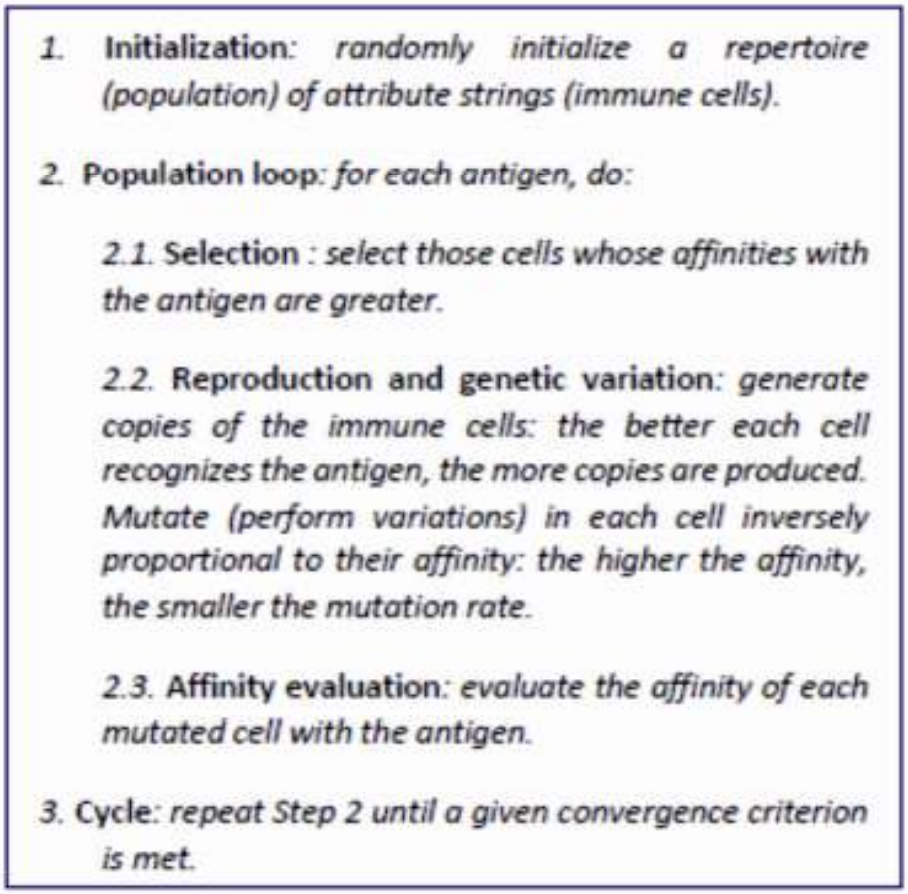

Figure 5 – Standard clonal selection algorithm

Formally algorithm of clonal selection can be represented as [30]:

$$\text{CLONALG} = (P^l, G^k, l, k, m_{Ab}, \delta, f, I, \tau, AG, AB, S, C, M, n, d) \quad (12)$$

where P^l is space of search (space of forms); G^k is space representation; l is the length of vector of attributes (dimension of space of search); k is the length of antibody receptor; m_{Ab} is dimension of population of antibodies; δ is the expression function; f is the affinity function; I is the function of initialization of the initial population of antibodies; τ is the condition of completion of algorithm work; AG is the subset of antigenes; AB is population of antibodies; S is the opera-

tor of selection; C is the operator of cloning; M is the mutation operator; n is the number of the best antibodies selected for cloning; d is the number of the worst antibodies subjected to substitution for new ones.

The process of converting a population of antibodies by clonal selection algorithm can be represented as a sequence of the following statements:

$$\begin{aligned} AB_t \xrightarrow{\text{Selection(S)}} G_S \xrightarrow{\text{Cloning(C)}} G_C \xrightarrow{\text{Mutation(M)}} G_M \\ \xrightarrow{\text{Repeat mutation(S)}} G_S \xrightarrow{\text{Replacement(d)}} AB_{t+1}, \end{aligned} \quad (13)$$

where t - is the number of generation, AB - is the population of antibodies (detectors), G_S - the subset of selected best antibodies, G_C - is the subset of clones, G_M - is the subset of clones after mutation.

Combined clonal and negative selection algorithm. The classifier presented in this paper is based on the hybridization process of negative selection with clonal selection, and was designed to solve problems of classification to many classes. Concept of classification is used in terms of supervised learning, which allows categorizing objects into known groups using training set prepared beforehand. The main task of every classifier based on supervised learning is to create an internal representation of classes (in the form of a function, set of rules or any other). It acquires it during training. When the training is completed the classifier is ready to produce an answer to any (known or unknown) pattern given subsequently.

In this study the efficiency of immune classifiersis researched, when as the classifier, in general, is a function that for attributes vector of object shall decide to which class it belongs [27]:

$$F : \Re^n \to Y. \quad (14)$$

The function *F* represents the space of sign vectors in the space of the class labels *Y*. In the case of two classes $Y = \{0,1\}$, '1' corresponding case of the detection event, '0' - the event is not detected. We consider the variant of training with a teacher (supervised learning), when the classifier training available to us a set of vectors $\{x\}$ for which is known their valid membership in one of the classes.

In developing this model treated the problem of developing an improved method of generation of detectors capable to adaptively select

their debugging and localization. This modification propose in a phase of training to optimize coverage by detectors set of "Non-self" via the mechanism of clonal selection. For the solution of the problem is introduced following submission of antibodies (Fig.6).

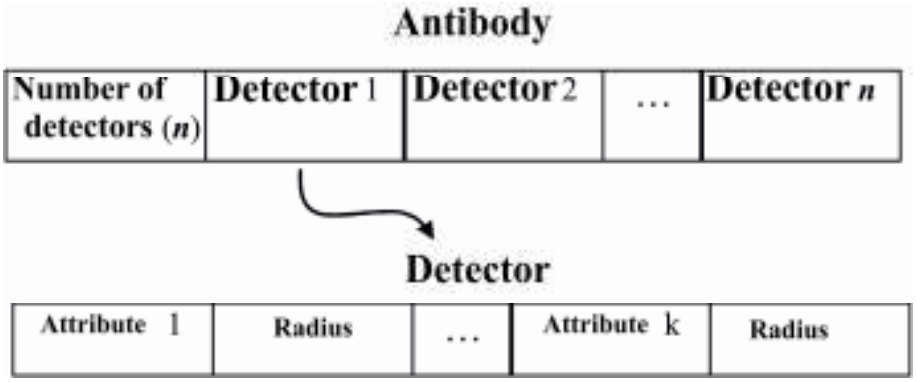

Fig. 6. View of clonal negative model antibody [28]

In this view, attributes are the coordinates of the center of the detector and the radius - the threshold sensitivity of the detector (cross-reactive threshold). Thus, each antibody encodes a possible alternative arrangement of detectors in space "Non-self", that option schemes covering. By manipulating the population of antibody-like structure, is the best option scheme covering. This algorithm is described in detail in [28].

3. Results and discussion

It is common practice in machine learning and data mining to perform k-fold cross-validation to assess the performance of a classification algorithm. K-fold cross validation is used among the researchers, to evaluate the behavior of the algorithm in the bias associated with the random sampling of the training data. In k-fold cross-validation, the data is partitioned into k subsets of approximately equal size. Training and testing the algorithm is performed k times. Each time, one of the k subsets is used as the test set and the other k-1 subsets are put together to form a training set. Thus, k different test results exist for the algorithm. However, these k results are used to estimate performance measures for the classification system.

The common performance measures used in medical diagnosis tasks are accuracy, sensitivity and specificity. Accuracy measured the ability of the classifier to produce accurate diagnosis. The measure of the ability of the model to identify the occurrence of a target class accurately is determined by sensitivity. Specificity is determined the meas-

ure of the ability of the algorithm to separate the target class. The classification accuracies for the datasets are calculated as in Eq. 15:

$$\text{Accuracy}(Z) = \frac{\sum_{i=1}^{|z|} \text{Assess}(z_i)}{|Z|} \tag{15}$$

while

$$\text{Assess}(z) = \begin{cases} 1, & \text{if calssify}(z) = z.c \\ 0, & \text{otherwise} \end{cases} \tag{16}$$

where z denotes the patterns in testing set to be classified, $z.c$ is the class of pattern z, $classify(z)$ returns the classification of z by classification algorithm.

For sensitivity and specificity analysis, the following equations can be used:

$$\text{Sensitivit y} = \frac{TP}{TP + FN} \tag{17}$$

$$\text{Specificity} = \frac{TN}{TN + FP} \tag{18}$$

where TP, TN, FP i FN denote respectively true positive, true negative, false positive and false negative classification.

In order to compare the efficiency of the proposed method in predicting the class of the cancer microarray data we have used three standard datasets such as All/AML Leukemia, Colon Dataset, Prostate cancer. All the datasets is binary class datasets. The feature selection process proposed in this paper has two steps. First the microarray data is decomposed by factor analysis optimally choose the discriminate feature set then using Discrete wavelet transform into level 4 using db13 wavelet to get the approximation coefficients as the extracted feature set. The performance of the proposed feature extraction method is analyzed with the well studied neural network classifiers such as MLP and RBFNN. The leave one out cross validation (LOOCV) test is conducted by combining all the training and test samples for both the classifiers with all the three datasets and the results are listed in Table 1. For this Data the performance of HCNA is comparable to RBFN and MLP.

Table 1

Comparison study of classification accuracy, sensitivity and specificity of HCNA with MLP and RBFN classifiers

Dataset	Method	Classification Accuracy	Sensitivity	Specificity
ALL/AML Leukemia	MLN	91.3%	98.21	97.01
	RBFN	98.4%	98.55	97.25
	HCNA	100%	99.06	99.20
Colon Dataset	MLN	94.5%	97.44	96.25
	RBFN	97.6%	98.10	97.10
	HCNA	99.7%	98.80	99.45
Prostate cancer	MLN	98.8%	98.03	97.21
	RBFN	97.2%	98.80	98.00
	HCNA	100%	99.10	99.60

The performance of the proposed method is also compared with those obtained by the recently reported methods and the results are listed in Table 2-4. The existing methods also used the cross validation test on the datasets. From Tables 2-4 it reveals that our method is equivalent to the counterparts with the advantage of reduced computational load. Weka [31]. Table 5 shows the decomposition stages upto 4th level by using db13 in discrete wavelet transform.

Table 2.

Comparison study of accuracy of Colon Dataset

Methods	Classification accuracy
Bayes Network	85.3%
Naive Bayes classifier	60.1 %
Multinomial logistic regression model	74.2%
Support Vector Classifier	94.3%
Class for doing classification using regression methods	91.8%
Simple Decision Table Majority Classifier	89.3%
1R classifier	73.9%
C4.5 decision tree	94.5%
Forest of Random Trees	97.4%
Factor Analysis + Wavelet + HCNA	99.7%

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Table 3.

Comparison study of accuracy of ALL/AML Leukemia dataset

Methods	Classification accuracy
Bayes Network	87.6%
Naive Bayes classifier	64.2 %
Multinomial logistic regression model	77.4%
Support Vector Classifier	91.3%
Class for doing classification using regression methods	97.6%
Simple Decision Table Majority Classifier.	92.5%
1R classifier	70.9%
C4.5 decision tree	96.5%
Forest of Random Trees	97.6%
Factor Analysis + Wavelet + HCNA	100%

Table 4.

Comparison study of accuracy of Prostate cancer

Methods	Classification accuracy
Bayes Network	91.7%
Naive Bayes classifier	69.2 %
Multinomial logistic regression model	80.5%
Support Vector Classifier	99.4%
Class for doing classification using regression methods	91.7%
Simple Decision Table Majority Classifier.	89.4%
1R classifier	69.2%
C4.5 decision tree	97.1%
Forest of Random Trees	98.8%
Factor Analysis + Wavelet + HCNA	100%

Table 5

Reduction details of the dataset

Dataset	**Original Dimension**	**Factor Analysis**	**DWT Db 13 Level 4**
Colon	62×2000	62×700	62×180
ALL/AML Leukemia	72×7129	72×700	72×180
Prostatecancer	136×12600	136×700	136×180

4. Conclusion

In this paper we have presented a hybrid feature extraction method using the Factor analysis in conjunction with wavelet transform to effectively select the discriminative genes on microarray data. A simple HCNA based classifier has also been introduced to classify the microarray samples efficiently. The comparison results elucidated that the proposed approach is an efficient method which performs better than the existing methods. Besides it has reduced computational complexity.

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FUZZY MODEL FOR DECISION-MAKING SUPPORT IN THE DETERMINING OF THE CHARACTERISTICS OF THE FINISHED PRODUCT

Abstract.The possibility of the use of fuzzy mathematics in hierarchy analysis technique is considered. A variant of hierarchy analysis technique on the basis of linguistic estimates in the determining of the characteristics of the finished product is proposed.

Key words: multicriterion problem, hierarchy analysis technique, alternatives, vectors of priorities, instruments of fuzzy mathematics, linguistic variables.

Introduction

When making managerial decisions and predicting possible results, a decision maker normally deals with a complicated problem of interdependent components, which is to be analyzed. The hierarchy analysis technique is a closed logical structure, which, by means of simple and valid rules, provides solving of multicriterion problems including both qualitative and quantitative factors, with quantitative factors having different dimensionality.

The aim of hierarchy analysis technique is justification of selecting the one best alternative among proposed ones, their characteristics being vectors with heterogeneous as well as fuzzy components [1].

The objective of research

The validity of the selecting of the finished product characteristics based on the combined usage of hierarchy analysis technique and fuzzy mathematics is analyzed in this research.

Presentation of main material

The primary stage in applying hierarchy analysis technique (HAT) is structuralizing of the choice problem as a hierarchy. The simplest way is creating a hierarchy from the top (objective) through intermediate levels (criteria) towards the lowest level which is generally a set of alternatives [1].

The questions of a peculiarity of antecedent factor ranking are developed in the article [2]. This method is convenient to use when estimating technical and economic characteristics choosing those of them

that have the greatest effect on decision-making in production of paving tile. Experts revealed 3 factors-criteria, that influence considerably a choice of a type of paving tile in the course of production and must be involved in further calculations. After hierarchical reproduction of a problem, priorities of criteria are established and each alternative is estimated according to criteria.

In our instant, the analysis of three types of paving tile: A, B, C was carried out according to their desirability. As a basis of comparison three main criteria were selected: price, quality, technical characteristics. As a result of expert evaluation, the decision was made about the dominance of the price of the product and its technical characteristics over its quality. Therefore the element (2.1) of the matrix A is instantiated 5, i.e. $a_{21}=5$. This automatically presupposes that $a_{12}=1/5$.

By designating P as price, Q as quality, T as characteristics – criteria, we are able to record the matrix of comparison in the following way:

$$A=\begin{array}{c} \\ P \\ Q \\ T \end{array}\begin{array}{c} \begin{array}{ccc} P & Q & T \end{array} \\ \begin{bmatrix} 1{,}00 & 5{,}00 & 5{,}00 \\ 3{,}00 & 1{,}00 & 3{,}00 \\ 0{,}20 & 0{,}33 & 1{,}00 \end{bmatrix} \end{array}$$

In similar way the elements of the matrices A_p, A_q, A_t are determined based on the judgements of a decision maker. Then the priority vectors on given matrices are calculated. Relative weights are calculated by way of average values of the elements of the corresponding lines of the normed matrix N, the elements of which are determined by division of the elements of each column of the dual comparison matrix into the sum total of the elements of the same column. Required relative weights W_p, W_q, W_t, of the criteria are calculated by way of average values of the elements of the corresponding lines of the normed matrix A. The sum total of the elements of this matrix`s first column equals 4.20; of the second column – 6.33; of the third – 9.

The relative weights of alternative decisions corresponding to the tiles A, B, C are calculated within each criterion P, Q, and T using comparison matrixes - A_p (sum total of the column elements equals correspondingly 9; 4.3; 1.5), A_q (sum total of the column elements equals correspondingly 1.5; 4.3; 9), A_t (sum total of the column elements equals

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correspondingly 9; 5.3; 1.5) and A_l (sum total of the column elements equals correspondingly 1.5; 4.3; 9). As a result we obtain the following normed matrix:

		Tile A	Tile B	Tile C
	Tile A	0.111	0.077	0.130
$N_{p=}$	Tile B	0.333	0.231	0.217
	Tile C	0.556	0.692	0.652

Average values of the elements in the lines $W_{p\ tile\ A}$ =0.106; $W_{p\ tile\ B}$ = 0.260; $W_{p\ tile\ C}$ = 0.633. By analogy, we create N_q, for which values - $W_{q\ tile\ A}$ = 0.106, $W_{q\ tile\ B}$ =0.260, $W_{q\ tile\ c}$ = 0.633; for N_t: $W_{t\ tile\ A}$ = 0.633, $W_{t\ tile\ B}$ =0.260, $W_{t\ tile\ c}$ = 0.106. Values $W_{p\ tile\ A}$, $W_{p\ tile\ B}$, $W_{p\ tile\ C}$ provide relative weights for types of tile according to its price.

By analogy, values $W_{q\ tile\ A}$, $W_{q\ tile\ B}$, $W_{q\ tile\ c}$ are relative weights, concerning with the quality of products, and $W_{t\ tile\ A}$, $W_{t\ tile\ B}$, $W_{t\ tile\ c}$ concern with technical characteristics. If the columns of the normed matrix are identical it means that primary comparison matrix is coherent. If a dual comparison matrix is not coherent, it is advisable to calculate an index of coherence for it, which provides information on the rate of coherence violation.

In our case, the matrix A_p is not coherent since the matrix N_p columns are different. We determine the value $n_{max.}$ because $\overline{w_1} = 0{,}106$; $\overline{w_2} = 0{,}260$; $\overline{w_3} = 0{,}633$, therefore:

$$A_{P_{\overline{w}}} = \begin{bmatrix} 1 & 0{,}33 & 0{,}2 \\ 3 & 1 & 0{,}33 \\ 5 & 3 & 1 \end{bmatrix} \cdot \begin{bmatrix} 0{,}106 \\ 0{,}260 \\ 0{,}633 \end{bmatrix} = \begin{bmatrix} 0{,}320 \\ 0{,}790 \\ 1{,}946 \end{bmatrix}$$

Hence, n_{max} *=3,055*. For *n=3, CI=0,027681; RI=0,66; CR=0,041941*.Since *CR<0,1*, the level of the matrix incoherence is acceptable. The estimation of alternatives is based upon calculating of the weight index.

tile A:	F tile A=	0,24	optimal
tile B:	F tile Б=	0,13	
tile C:	F tile B=	0,14	

On the basis of these calculations the tile A obtains the highest combined weight and, therefore, is the most optimal choice of a decision maker.

Ranking (regulation according to preference) of all variants is represented graphically in the Fig. 1.

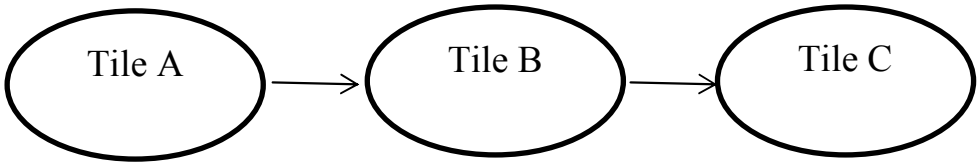

Figure 1 – Regulation of variants according to preference according to hierarchy analysis technique.

Within hierarchy analysis technique there are no general rules for forming of decision-making model structure. The framework of the technique appliance does not depend on the scope of activity, in which a decision is made. It makes the technique multipurpose, its usage allows to organize the system of decision-making support [3].

The theory of hierarchy analysis technique has a number of disadvantages, gaps and erroneous assumptions. One of these is that the scales of the preference strengths estimating (measuring) of variants according to each criterion are established as ratio scales, being nonrelated to each other and to criteria priorities. Thus, there exists an obvious necessity of developing, based on the theory of criteria importance, valid and effective methods of solving multicriterion problems with hierarchical criterion structure and realization of these methods in computer systems of decision-making support.

For solving this problem we shall use instruments of fuzzy mathematics [4-5]. Hierarchy analysis technique, being a technique of solving multicriterion problems in complex conditions with hierarchical structures comprising nonformalized elements, is used as an indirect method for determination of fuzzy set adjectives. Utility function is not regarded as a probability function, but as a fuzzy value, fuzzy set adjectives being considered as subjective estimations of decision makers (DM).

Formally, the problem of multicriterion choice can be represented as a triple of objects [1, 3]:MS=<G, C, A>, where G is a goal of a multicriterion choice problem; C – criterion set; A – alternative set.

When decreasing the number of criteria, included in the system of preferences, the complexity of dual comparison matrices in hierarchy analysis technique increases considerably. As a means of the indicated problem it is possible to use decomposition-aggregate approach to solving multicriterion problems, when a complex criterion, being a subgoal of a general multicriterion choice problem, is subdivided into less complex ones [6].

If each criterion is regarded as a linguistic variable, the alternative set is $A = \{A_1, A_2, ..., A_n\}$, the criterion set - $C = \{C_1, C_2, \ldots, C_m\}$. For each *i*-criterion the linguistic variable is L_i with termal set $T = \{T_{i1}, T_{i2}, \ldots, T_{it}\}$, where the semantics of each term $\mu_{ij}(x_i) : X_i \to [0,1]$, $X_i \in [x_i^{inf}, x_i^{sup}]$, - of basic set of linguistic variables for an *i*-criterion x_i^{inf}, x_i^{sup} - lower and upper limit of a basic set correspondingly.

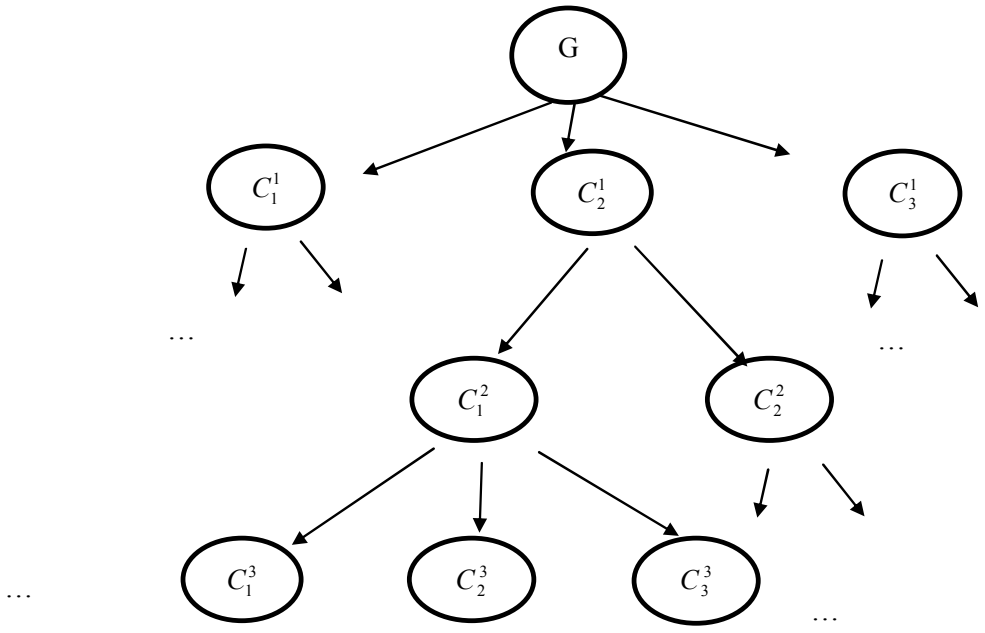

Figure 2 – The hierarchy of the multicriterion choice preference system of a decision maker for paving tile (*G – choice of product,* C_1^1 *- a way of tile paving;* C_2^1 *- method of production;* C_2^3 *- attractiveness;* C_1^2 *- subgoal–vibropressing;* C_2^2 *- subgoal– vibrocasting;* C_1^3 *- subgoal – quality;* C_2^3 *- subgoal –price;* C_3^3 *- subgoal –characteristics*)

Designations of the terms of the linguistic variable L_i are qualitative characteristics of tha criterion C_i, in our case: L_1 = (quality= {not

bad, satisfactory, high}), L_2 = (price = {low, medium, high}), L_3 = (characteristics {not bad, satisfactory, excellent}).

To estimate the effectiveness of an alternative according to a separate criterion, a linguistic variable E is introduced, it has a termal set $S = \{S_1, S_2, \ldots, S_t\}$, its capacity coincides with T_i, and it is also invariant relating to each criterion C_i. Semantics of the terms - $\mu_{S_k}(y) : Y \to [0,1]$; где $Y \in [0,1]$ - basic set of a variable E, $k = \overline{1,t}$ - numbers of terms.

Consolidating of estimates on different levels (Fig.2) is exercised according to the approach in the research [6], after convolution of criteria within a subgoal, and an optimum alternative for a subgoal is selected according to $A^*_{\text{пц}} = \max\limits_{d\in[1,n]} \delta^d_{s''+(m-s'')}$, where d is a number of an alternative. After transforming of all subgoals into a criterion on the k – level, the level, where convoluted criteria are placed, is destroyed and a number of levels is decreased by 1.

Then the global priority vector is determined. Aggregation (consolidation) of alternative estimates after transformation of a preference system structure of a decision maker with the aim of selecting the best alternative using the principles of optimum choice, is performed in the following way: $A^*_G = \max\limits_{d\in[1,n]} \delta^d_G$, where δ^d_G - estimate of the alternative d according to a goal of multicriterion choice G [6].

After performing calculations we find, that evaluating the alternatives, the optimum way is production of paving tile by means of vibropressing, quality, price, characteristics, a way of paving and attractiveness reaching a predetermined level.

Conclusions

The proposed variant of hierarchy analysis technique, involving applying of linguistic estimates of the quality of alternatives separately by criteria and different convolutions of local priorities at the level of aspects, allows to include semi-structured data in the process of multicriterion analysis. It is shown that hierarchy analysis technique may be used effectively not only for decision making in non-formalized spheres and solving of ranking problems of a final set of complex objects represented in the form of hierarchical structure, but also for decision mak-

ing in problems where formalization of all fuzzy notions by means of fuzzy sets is required.

The approach is performed based on the data of a particular enterprise, the model proposed allows to perform calculations using modern informational technologies.

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V.I. Silkov, A.V. Samkov

THE ALGORITHM FOR CALCULATINGTHE CHARACTERISTICS OFTHE TAKE-OFFFROM THE SPRINGBOARD UAV

Abstract.The article presents the technique calculation of kinematical parameters the unmanned aerial vehicle (UAV) at take-off with springboard. The influence on these parameters some characteristics of the unmanned aerial vehicle is analyzed

Keywords: unmanned aerial vehicle, control takeoff from a springboard, parameter optimization springboard

The rapid development of unmanned aircraft recently significantly expanded the list of volumes and solved problems. One of the measures for the empowerment use of unmanned aerial vehicles (UAVs) in a lack of the necessary platform for its take-off may be the use of special springboards.

Their use is justified for ships with decks which will run UAV in mountainous and forested areas where they are based, etc.

In addition, by creating a springboard for the initial vertical velocity allows takeoff UAV with greater payload mass.

In the particular case by increasing the supply of fuel on board the UAV can increase its range and duration of the flight or by installing additional equipment - to expand the list of solved tasks.

Special springboards for takeoff manned aircraft have been used successfully since the early eighties of the last century, primarily for the needs of military aviation ship basing [1 … 5].Their use could reduce the safe speed of lift-off, reduce the length of run, increase the payload on board, etc.

Obviously, it is advisable to use the advantages of a springboard for unmanned aircraft based on its specific characteristics that require the development of special methods and techniques of calculating the characteristics of takeoff from the springboard for specific UAV.

The article presents the technique calculation of kinematical parameters the unmanned aerial vehicle (UAV) at take-off with springboard.

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The springboard is usually a small sloping area, which is a continuation of a section horizontal runway (Fig. 1). The inclined section can be flat or curvilinear.

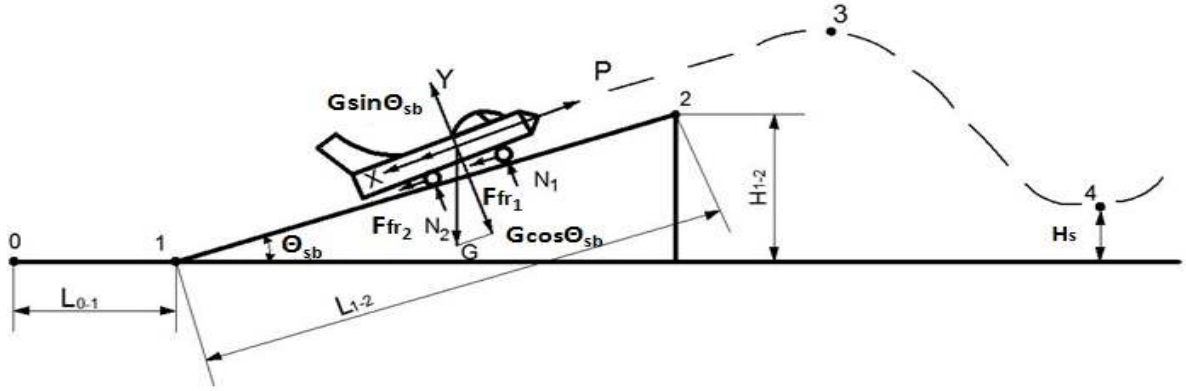

Fig. 1. Scheme take-off from the springboard

The take-off from the springboard has two important peculiarities, which distinguishes it from a conventional take-off at moment of lift-off:

First, the lift force of UAV is considerably below the weight owing to small velocity;

Second, the UAV at moment of lift-off has a certain initial angle θ, which is equal to angle of springboard at end-point 2 (fig.1).

After lift-off the UAV moves along a trajectory, which is close to ballistic curve, at the beginning with height increasing (point 3) and then comes down up to safe value with increasing of velocity. The take-off must be organized thus, that with a decrease in a height, in point 4, the UAV possessed an enough reserve of height and velocity, which can provide a safety prolongation of flight. The safety prolongation of flight will be depend on like parameters of UAV (the value V2, thrust-to-weight ratio of UAV μ, maximal coefficient of lift force), so and characteristics of springboard (its length and angle of slope). These characteristics must be given for each concrete UAV.

At the same the characteristics of existing springboards will set certain requirements for different types of UAV with their dimensions and weight, aircraft performance and operational characteristics. Changing the speed during the run-up describes the known equation[I]:

$$j_x = \frac{dV}{dt} = g(n_{xa} - \sin\Theta)$$

where $n_{xa} = \frac{P_x - X_a - F_{fr}}{G}$.

So, at process of running start an angle of attack is constant, and the difference of friction force (Ffr) and drag force (Xa) is approximately constant.

If vector of thrust is not rotated at process of running start, then a longitudinal overload (nxa) can consider constant.

From mechanics it's known, that for uniformly accelerated motion a length of traversed path (L_{0-1}) is connected with end speed (in point 1) with help next dependence:

$$L_{0-1} = \frac{V_1^2}{2j_{mid}}, \quad (2)$$

where

$$j_{mid} = gn_x = g(\mu_x - f_{rf}) \quad (3)$$

$\mu_x = \frac{P_x}{G}$ - an average thrust-to-weight ratio of UAV;

j_{mid} - average acceleration in direction of motion;

$f_{rf} = 0.5(f + \frac{1}{k_1})$ -Reduced factor of friction.

This factor takes into account a resistance for UAV motion owing to runway (through factor of friction f) and ram air (through lift-drag ratio in end of horizontal section K1). After horizontal section it's - an itself springboard. Its surface may be flat (fig. 1) or curvilinear (fig. 2).

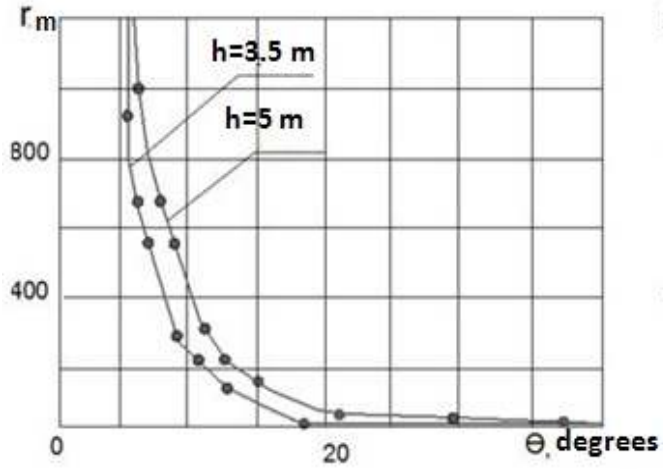

Fig.2. Dependences a radius from the end angle of springboard

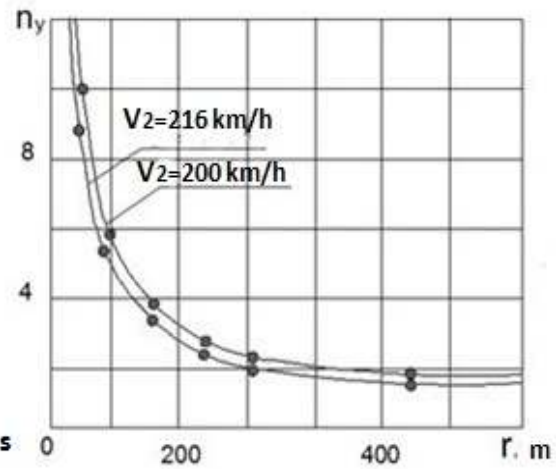

Fig. 3. Dependence the value overload n_y from radius r

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Thus a height (H_{1-2})of springboard must be restricted because of its mass parameters, of constructive and other conditions, for placing it on the concrete object. The motions on flat and curvilinear springboards have their peculiarities. The length L_{1-2} and the height H_{1-2} of flat springboard are connected through obvious dependence:

$$L_{1-2} = \frac{H_{1-2}}{\sin \Theta_{sb}} \tag{4}$$

At motion on springboard on UAV acts a constant force $G \cdot \sin \Theta_{sb}$ which decreases the acceleration by value $\Delta j_{пп} = -g \sin \Theta_{sb}$, In this case common acceleration is equal $j_x = j_{mid} - g \sin \Theta_{sb}$. So, the value $g \sin \Theta_{sb}$ is constant, general motion remains uniformly accelerated and changing of the velocity can write as:

$$V_2^2 - V_1^2 = 2j_x L_{1-2} = 2j_{mid} L_{1-2} - 2gL_{1-2} \sin\Theta_{sb} = 2j_{mid} L_{1-2} - 2gH_{sb}. \tag{5}$$

Second summand determines a value of a speed loss because of a slope angle springboard. From formulas (1-4) follows, that a value of UAV acceleration, in process of running start, is basically determined by a thrust-to-weight ratio and slope angle springboard.The more UAV has acceleration, the shorter path for take-off (fig.3).

If the springboard with curvilinear surface (fig. 2), then angle will change from 0 to Θ_{sb}. The decelerating force $G \sin \Theta$ will increase gradually from 0, at the entrance to the springboard, to the value $G \sin \Theta_{sb}$ in the end.

Since the force $G \cdot \sin \Theta$ has an influence on kinetic energy at climb, therefore a loss velocity from action this force don't depend on a form of springboard, and is determined only its height (see (5)).

Let us suppose that the curvilinear segment of springboard presents a cylindrical surface with constant radius and its height is restricted up the value H_{sb} owing to constructional considerations (see fig. 4). So, we can calculate

$AB = r \cdot \cos\Theta_{sb}$, $B1 = r$, $H_{sb} = r - r\cos\Theta_{sb}$. Further we can determine a connection between radius (r), of height (H_{sb}) and an end angle of springboard:

$$r = \frac{H_{sb}}{1 - \cos\Theta_{sb}}. \qquad (6)$$

According to 6 the bigger value of angel Θ_{sb}, the less radius of-springboard must be (at certain height).

Dependences a radius from the end angle of springboard for values H_{sb}=3.5 m and H_{sb}=5 m are shown in fig.2.

As it follows from calculation, the most strongly the angles Θ_{sb} affect on a value at small angles Θ_{sb}.So, at increasing of angle Θ_{sb} from 7° to 20° the value r should decrease approximately from 600 to 90 (m), i.e. nearly sevenfold.

However, at decreasing r should grow the values of centripetal force and normal overload (n_y), which act on the UAV.

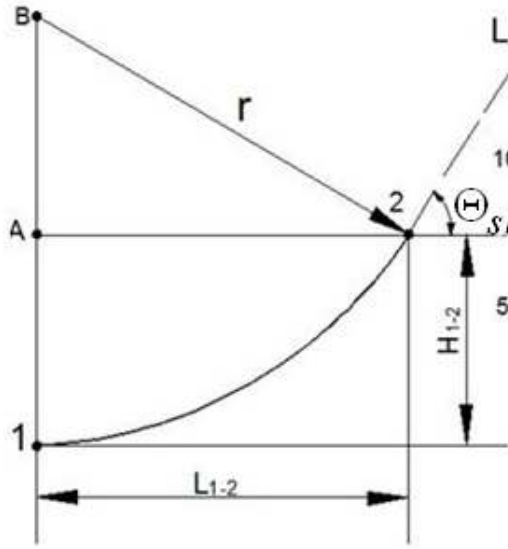

Fig. 4.Dependence the radius r from the end-angle of

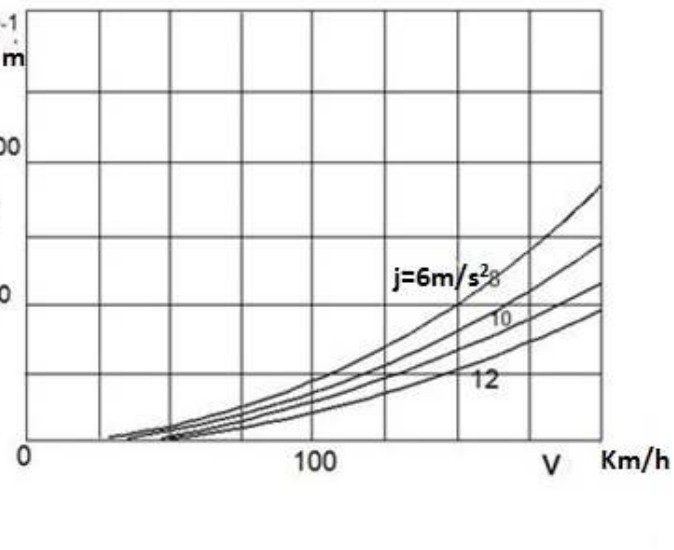

Fig. 5. Dependence the length of horizontal sector from a velocity

Since a velocities of UAV are small at process of running start, then an overload is created mainly of the normal reactions of springboard N=N1+N2, which act on chassis of UAV (fig. 1). As known, the

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curvilinear character of UAV motion is determined centrifugal $\frac{mV^2}{r}$ and centripetal forces $Y + P_y + N - G \cdot \cos\Theta$. From their equality it is possible to receive expression for radius of curvature[1]:

$$r = \frac{GV^2}{g(Y + P_y + N - G \cdot \cos\Theta)} = \frac{V^2}{n_y - \cos\Theta}, \quad (7)$$

where $n_y = \frac{Y + P_y + N}{G}$.

Dependence a normal overload ny from radius curvature of springboard is shown in fig. 3. As it follows from calculation the normal overload begins increase intensive at decreasing a radius below 100 m. So, if the UAV will move up to curvilinear trajectory with radius 100 m, then overload will be $n_y = 4$.

If a value r is equal 50 m, then at same velocity (V2=200 km/h) on the UAV should act an overload $n_y = 7$.

Naturally, that a control of the UAV with such overload is difficult. From (7) follows that at constant r an increment of overload will increase approximately proportional square of velocity, i.e. maximal value of overload the UAV will test in end of springboard. Thereby,for decreasing of overload on the UAV, the springboard can do with variable radius: a small in the beginning and an increased r in end part. So, at moving along curvilinear trajectory, the angle velocity of turn trajectory will be determined a linear speed and a value r.

$$\frac{d\Theta}{dt} = \frac{V}{r}. \quad (8)$$

The path, traversed along curvilinear section of springboard, can determine as length of arc 1-2 (fig. 4):

$$L_{1-2} = r \cdot \Theta = \Theta. \quad (9)$$

Received formulas allowed to develop analgorithm for calculation of characteristics of UAV's take off from springboard. Based on the algorithm the methodology of calculation was developed.

It is possible to conduct the optimization of parameters at the springboard for different kinds of UAV's by using this method.

Taking into account constant changes of weather conditions of flights and requirements to flight task succeeding, which cause change of weight and dimension, operational and other features, this method must be implemented on the Decision Support System (DSC).

DSC use considering realspringboard's and UAV's characteristics, flight tasks requirements will enable to issue recommendations concerning payloadof UAVs and peculiarities of control of take-off with springboard

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I.V. Stovpchenko, A.I. Mihaliov, M.V. Gubinsky

MIMO-BASED CASCADE NEURAL NETWORK IDENTIFICATION OF OXYGEN CONVERTERS MELTING STEEL

Abstract.The article deals with the problems of identification of parameters of technological processes, metallurgy, namely steel production in the basic oxygen furnace. Also as part of this article formulates and put to the task of identifying of chemical characteristics of steel using a hybrid artificial neural network with a cascade architecture.Data was processed for the oxygen-converter process of steel smelting. Given and analyzed the results of identification.

Keywords: identification, modeling, cascade network, neural network, MIMO, neo-fuzzy, a hybrid ANN,oxygenconverter,steelmaking.

Introduction

The process of steelmaking in basic oxygen convertor is a complex nonlinear multivariable object of study , as it is shown in several studies [1, 2].

The essence of converter production lies in blowing of the molten iron with oxygen, as a result of which the elements of iron - carbon, silicon, manganese, phosphorus and others are oxidised and reaction products pass into the slag and gas phase. These processes in their turn are made either by contact of molten metal with a gaseous medium, which is a carrier of oxygen , or by the contact of molten metal with oxide phases or solid [3].

To reduce the oxygen content, the steel is deoxidized at the outlet of the converter, i.e. elements with larger affinity to the oxygen than that of the iron are introduced (Si, Mn, Al). While interacting with iron oxide FeO, they form insoluble oxides MnO, SiO2, Al2O3 later transferring into slag.

In turn, the calculation of the required amount of molten iron, scrap, slag-forming materials (e.g. blending fusion) is carried by the operator in terms of the conditions obtained at the end of the purging of carbon, sulfur, phosphorus, and temperature, as well as basic slag, required for this brand of steel. Blending of batches is made with the help of nomograms, special lines and accounting of the results of the previous heat. By this methods of work much depends on the experience

of that smelting the steel.

On the other hand, the continuous and reliable control of the output value of the converter by the existing means are often not provided, and, as a consequence, for the achievement of the purpose of identification these parameters are substituted by functionally related unmanaged outputs of the object, details of which are relatively easy to control.

According to the mentioned above the actuality (topicality) of solving the problem of identification of the chemical characteristic of steel, on the basis of computational intelligence techniques [2], namely, artificial neural networks with cascade architecture stands [4].

It follows the urgency of solving the problem of identification of chemical characteristics of steel output, based on artificial neuron networks with cascade architecture. To do this, first of all , you need to build and explore in general nonlinear mathematical model of oxygen-converting process , which should include only the most important characteristics of the technological process , the core of which is a neuro- architecture that directly facilitates the identification of output parameters of the model. It should be remembered that the excessive complexity of the model leads to a deterioration in the quality of identification [7].

The most important parameters of the oxygen-converting steel melting process are the neuromodel inputs, and the chemical characteristics of the resulting steel are the outputs. After this, you must configure the synaptic weights of the neural network, using a particular training procedure.

In this article we formulate and state the task of identification the output chemical characteristics of steel, gained through the oxygen-converting process of its smelting using the hybrid artificial neuron network with cascade architecture (fig.1), the results of identification are analyzed.

Identification of the steelmaking parameters in a converter

To identify the output parameters of steel, produced in the process of oxygen-converting smelting, it is necessary first of all to identify what data have the most significant impact on the composition of the steel output, as during the process of smelting nearly hundreds of different parameters are recorded into the database (input data, output

data, intermediate data). Naturally, unmotivated use of all of them will lead to an inadequate complexity of the neuro-model. And the error rate , respectively, will be excessively large. Besides, according to the expert information, it is known, that the most important parameters of the oxygen-converting process are:

1) the weight of iron poured into the oxygen converter;

2) the chemical composition of cast iron, namely such constituents as

- silicon (Si);
- manganese (Mn);
- sulfur (S);

3) The mass of metal that is loaded into the oxygen converter;

4) the duration of steel purging;

5) The chemical composition of steel at the first turndown, namely such constituents as

- silicon (Si);
- manganese (Mn);
- sulfur (S);

6) the amount of added deoxidizer :

- ferromanganese (FeMn);
- ferrosilicon (FeSi);
- silico (SiMn);
- aluminum (Al).

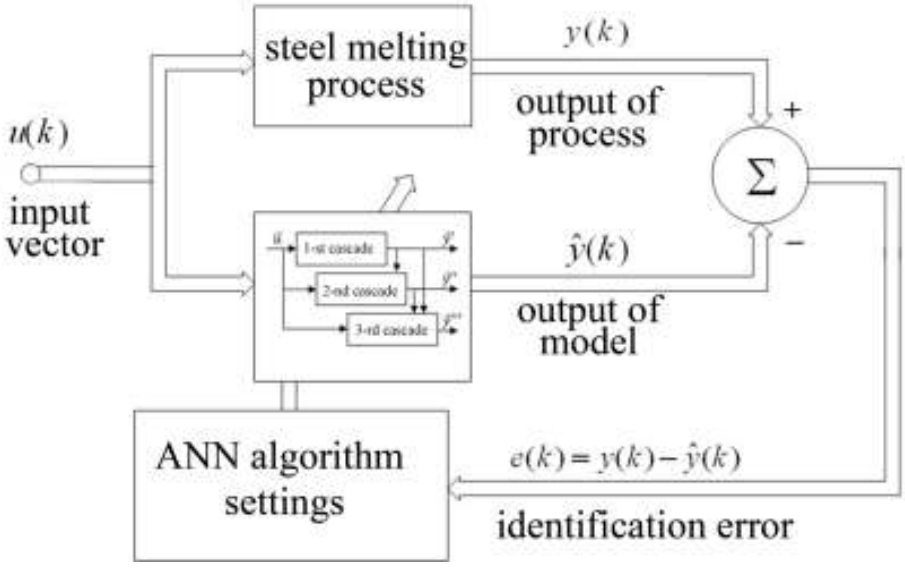

Fig.1. – The diagram of the identification system with a model in the form of hybrid artificial neuron network with cascade architecture.

There can be several stages of adding the reductants and subsequent measurement of the parameters of steel in the process described.

For definiteness, in this research the melting with only one stage was considered. This case is the most appropriate at the production, because it optimizes the time of steelmaking and reduces the consumption of materials that are used as reductants . The number of stages of deoxidation depends on how accurately the master of production determines the number of reductants .

It is necessary to perform the identification of the following chemical characteristics of the output:

1) amount of carbon in the readymade steel;

2) amount of manganese in the steel;

3) amount of silicon;

4) amount of sulfur;

5) amount of phosphorus.

During the identification of parameters of steel-making process in the oxygen converter the real data about the technological process were used. The sample contained information on 3273 smeltings in the oxygen-converting process under condition that one step of deoxidation was made earlier.

To solve the problem of the identification of the of steel obtained by the oxygen-converting process the multidimensional cascade neo - fuzzy neural network with 13 inputs and 5 outputs was used [1,2,4] . Neuro-architecture consisted of three cascades, each consisting of five neo -fuzzy neurons [4-6].

Inputs and outputs in the sample were normalized to the interval [0, 1], then the entire sample was divided into a training (2000 items) and testing (1273 items). To calculate the efficiency of solving the problem of identification the chemical composition of the steel obtained by the oxygen-converting process, the error was used:

$$e_j = \frac{1}{n}\sum_{i=1}^{n}\left|y_{ij} - \hat{y}_{ij}\right|,$$

where n - the size of the training sample, and j –the cardinal number of output parameter of cascade neural architecture.

y_{ij}, $\hat{y}_{ij}$ real and projected output parameters.

The results are shown in Table 2.

Additionally, to improve the accuracy of controlling the output signal the measure is proposed, which describes the amount (percent-

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age) of the examples in the test sample , for which the error of the network output was more than 10% of the normalized data. The inspection results are shown in Table 3 for each output chemical characteristic of steel.

Table 1.

The results of identification the chemical composition of steel

Sampling	The identifying error of steel composition				
	Carbon, C	Manganese, Mn	Silicon, Si	Sulfur, S	Phosphorus, P
Training	0.031	0.024	0.007	0.025	0.038
Testing	0.033	0.023	0.006	0.028	0.037

Table 2.

The results of the application the control measures for chemical identification of steel composition

Number of examples for which the error is> 10%,%				
Carbon, C	Manganese, Mn	Silicon, Si	Sulfur, S	Phosphorus, P
4.2	2.3	0.3	1.8	5.5

Findings

The proposed MIMO- cascade neo -fuzzy neural network , which differs from its prototype - cascade neo -fuzzy neural network –became the possibility of solving multidimensional input and the output (MIMO) tasks. On the basis of neo -fuzzy neural algorithms described [1,2,4], the problem of identifying the output characteristics of the steel obtained by the oxygen-converting technology is solved . The experimental results confirm the effectiveness of MIMO- cascade neo -fuzzy neural network to identify the process of steelmaking in basic oxygen convertor.

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V.B. Zvorykin, G.Y. Stanchits, V.F. Balakin

MODELLING PROCESS OF CONTROL OF ENGINE SPEED WITHFLEXIBLECONNECTIONOF THE ENGINE WITH THE MECHANISM

Abstract.Questions of a speed control of the engine in system of the subordinated regulation in the presence of flexible connectionof the engine with the mechanismare considered. Limits of stability are defined. The regulator of the speed is calculatedfor rather small ratios of inertial masses (inertia coefficient less than 5.8). It provides the greatest damping of fluctuations in system. It is shown that in this case the type of transient is defined by only a coefficient of a ratio of inertial masses.

Keywords: systems of the subordinated regulation, a speed control, two-mass system, flexible connection, damping of fluctuations.

It is often supposed at creation of the systems of automatic control (SAC) of speed that kinematic connection between the engine and executive mechanismisn't subject to flexible deformations. In most cases the similar assumption based on representation of rigid connection of the engine and executive mechanism, is admissible. It is connected with that the frequency of own flexible fluctuations of the mechanism often is much higher than a frequency, a control system defining speed of the electric drive.

In some cases the coefficients of rigidity of mechanical links is rather small. Thus elasticity and deformation of links become essential and can have considerable impact on transients in the electric drive. Installations in which the engine connects to inertial masses through obviously expressed flexibleelement can be examples: long shaft, the conveyer belt, long cable in lifting mechanisms. At this SAR of speed it is necessary to consider as two-mass system taking into account influence of flexibilityand gaps in mechanical links on electric drive movement.

We will consider the block diagram of SAR of speed in the presence of flexibleconnection of the engine with the mechanism (figure 1). In figure 1 contour of current is presented in the curtailed look.

For the further analysis we will make the following assumptions:

- · current contour don't have inert ion $W_m^3(p) = 1$,

- · speed regulator is the proportional $W_{pc}(p) = K_{pc}$.

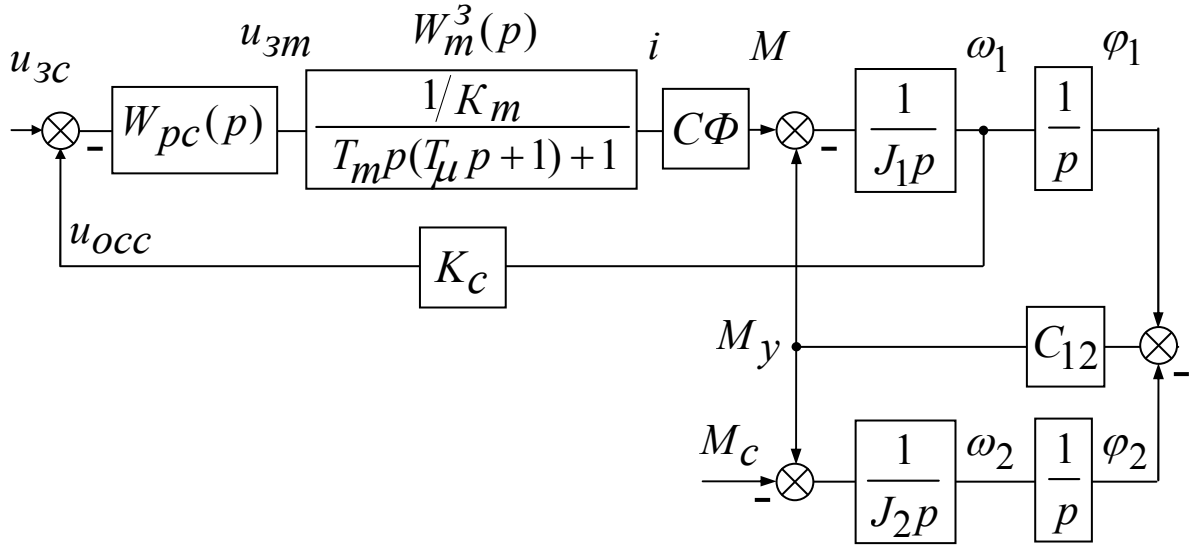

Figure 1 - The block diagram of SAR of speed of two-mass model of the electric drive without gap and viscous friction

We use system of relative units for simplification of the analysis of transients in SAR. After transformations the block diagram will assume the next type:

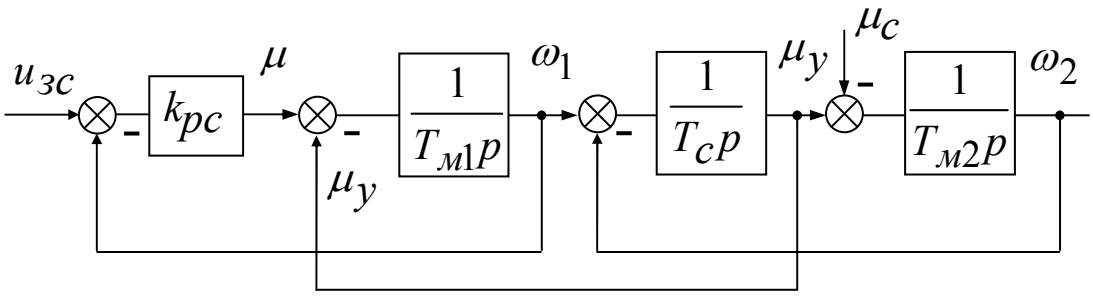

Figure 2 - The block diagram of SAR of speed of two-mass model of the electric drive in relative units

We will transfer internal points of the flexible moment through branching knots to an entrance and an exit of system of regulation. The corresponding block diagram is represented in figure 3.

We will determine transfer function of closed SAR of speed by control and we normalize it across Vyshnegradsky, by replacement $p = s\Omega_O$. Aftertransformationswewillreceive:

$$W_з(s) = \frac{\omega_2(s)}{u_{зс}(s)} = \frac{1}{s^3 + As^2 + Bs + 1}. \qquad (1)$$

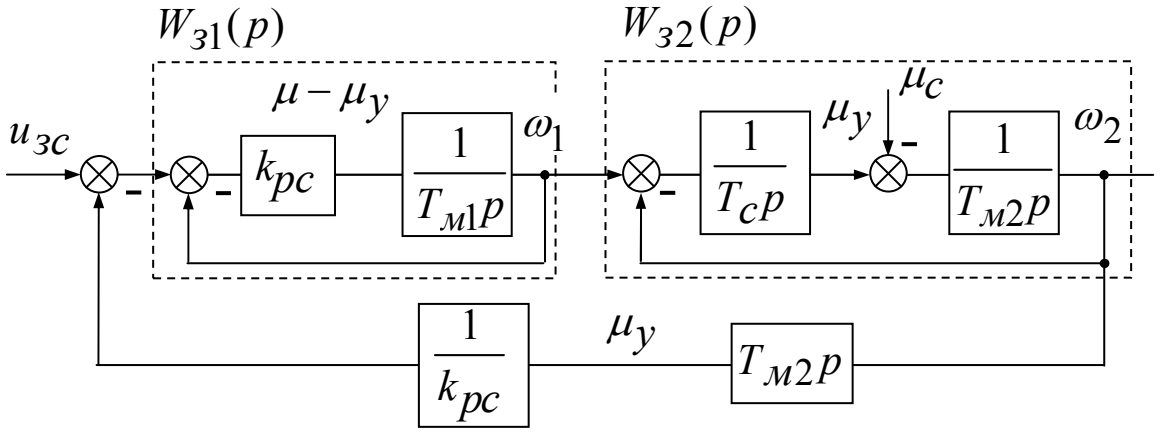

Figure 3 - The transformed block diagram of SAR of speed

Vyshnegradsky's coefficients A and B also will be defined:

$$A = \sqrt[3]{\frac{k_{pc}^2 T_c (\gamma - 1)}{T_{м1}}}, \tag{2}$$

$$B = \gamma \sqrt[3]{\frac{T_{м1}}{k_{pc}^2 T_c (\gamma - 1)}}, \tag{3}$$

where $T_{м1}$ and $T_{м2}$ - respectively, the electromechanical constants of time caused by inertia of the first and second masses; T_c - constant of time of rigidity of kinematic connection; $\gamma = \frac{T_{м2} + T_{м1}}{T_{м1}}$ - inertia coefficient, k_{pc} - coefficient of strengthening of the regulator of speed.

From formulas (2) and (3) follows:

$$AB = \gamma . \tag{4}$$

The chart Vyshnegradsky let to judge about nature of transientsin regulation system at change of coefficient of strengthening of the regulator of speed (figure 4). Lines of equal value of coefficient of damping $\xi_э$ are put on the chart plane with continuous lines, lines of equal value of coefficient of inertia γ - strokes.

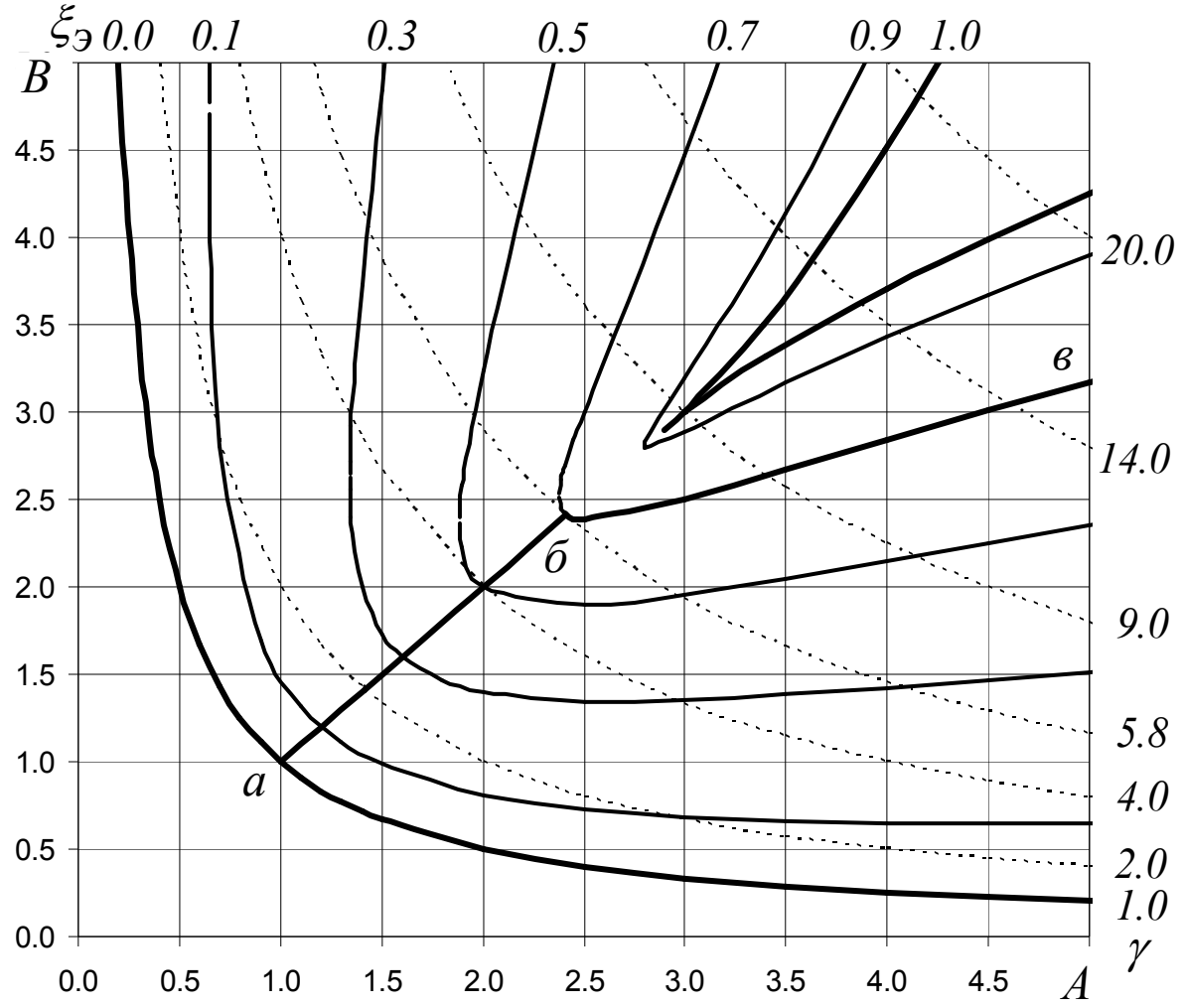

Figure 4 - Vyshnegradsky's chart

At change k_{pc} changed coefficients A and B, the working point on the plane of the chart of Vyshnegradsky moves on a characteristic curve in the form of the equilateral hyperbole. Its situation on the chart is defined only by inertia coefficient γ.

At $\gamma = 1$ a characteristic curve $AB = 1$ coincides with limit of oscillatory stability of system. It specifies that at values $\gamma < 1.2$ damping ability of the electric drive, irrespective of k_{pc}, will be insignificant.

It is obvious as characteristic curves $AB = \gamma$ settle down on all plane of the chart, there is a ratio of parameters of system at which movement of executive mechanism (the second inertial mass) will be smooth (without dissipative forces), despite existence of flexible communication.

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At rather small sizes γ it is expedient to chooseso value k_{pc} to provide probably bigger value $\xi_э$. For this purpose the working point on the chart has to belong to a straight line $аб$, on which equality $A = B$ is carried out. Value k_{pc} in this case will be defined from expression:

$$k_{pc} = \sqrt{\frac{T_{м1}}{T_c(\gamma - 1)}\gamma\sqrt{\gamma}}\,. \qquad (5)$$

Transitional functions of system at such choice k_{pc} are defined only by value γ (figure 5).

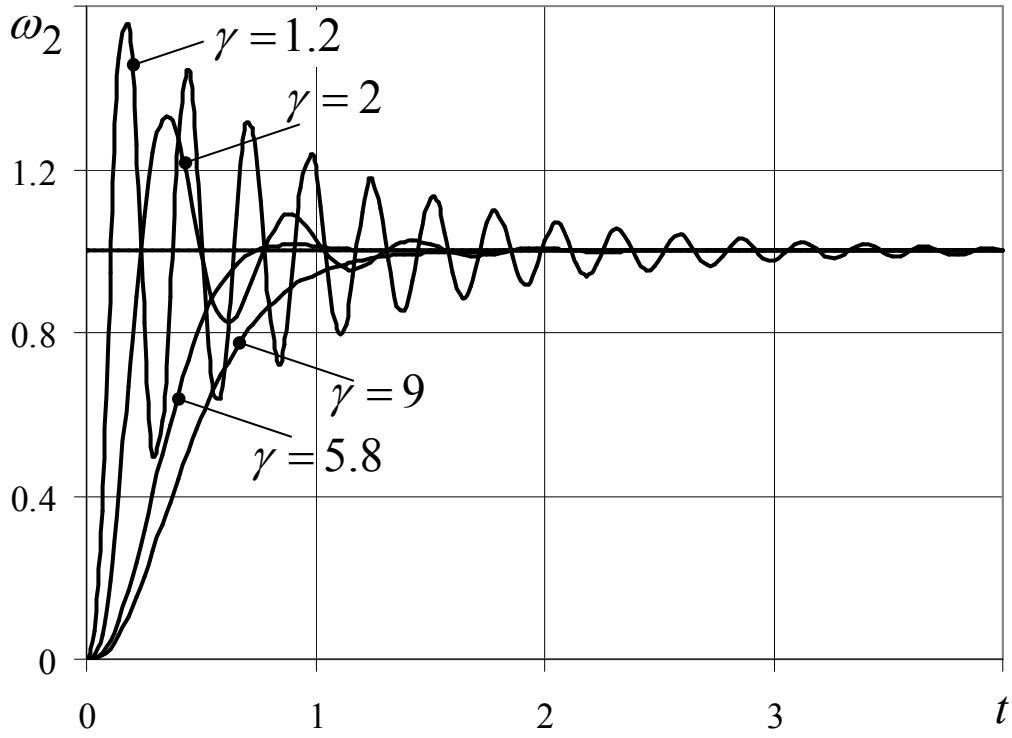

Figure 5 - Change of speed of executive mechanism at a choice k_{pc} on a formula (5)

From figure 5 follows that at $\gamma > 2$ fluctuation of speed of executive mechanism are damped by the electric drive. At $\gamma = 5.8$ coefficient

of damping $\xi_Э = 0.707$ and reregulation it is close to control for a modular optimum. At $\gamma = 9$ fluctuation in system are absent.

Conclusions

The type of transients in speed SAR in the presence of flexible connection of the engine with the mechanism, and a choice k_{pc} by a formula (5) is determined only by value of coefficient of inertia γ. The quality of regulation processes can be divided into two groups on influence of coefficient of inertia:

- transients at small coefficients of a ratio of inertial masses $\gamma < 5.8$ (the electric drive poorly damps fluctuations in system),
- transients at big coefficients of a ratio of inertial masses $\gamma > 5.8$ (damping ability of the electric drive is considerable).

LITERATURE

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СОДЕРЖАНИЕ

МАТЕМАТИЧНЕ ТА ПРОГРАМНЕ ЗАБЕЗПЕЧЕННЯ ІНТЕЛЕКТУАЛЬНИХ СИСТЕМ

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РЕФЕРАТИ

УДК 577.359

Чиженкова Р.А. **Математичний аналіз бібліометричні показників публікацій з нейрофізіологічним ефектам неионизирующей радіації різних видів (Medline-Internet)**// Системні технології. Регіональний міжвузовскій збірник наукових праць. – Випуск 6 (83). – Дніпропетровськ, 2012. – С. 3–11.

Представлені бібліометричні дані по нейрофізіологічним публікаціям щодо впливу неионизирующей радіації різних видів (ЕМП, поле СВЧ , МП і ЕП). Розглянуто кількісні характеристики публікацій обраних напрямків за 35 -річний інтервал часу (1966-2000 рр..). Проаналізовано динаміку чисел публікацій зазначених типів. Зроблено висновок про перспективи нейрофізіологічних досліджень дії неіонізуючих випромінювань.

Бібл. 16, табл. 7.

УДК 004:371.71

Вишемирська С.В. **Методологічні основи побудови інформаційних систем і технологій управління станом здоров'я студента** // Системнітехнології. Регіональнийміжвузовскійзбірникнауковихпраць. – Випуск 6 (83). – Дніпропетровськ, 2012. – С. 12–22.

Розглянуто методологічний підхід до процесу індивідуалізації управління станом здоров'я студентів. Підхід використовує аналіз широкого кола показників здоров'я з їх подальшим узагальненням з метою формування інтегрального індексу оцінювання рівня здоров'я студента та розбиття множини студентів на групи, в яких використовуються різні методики, комплекси вправ та їх інтенсивність.

Бібл. 8, іл. 4.

УДК 681.004.89:164.053

ВишемирськаС.В.**Ціноутворення як елемент системи управління підприємством дитячого харчування**// Системні технології. Регіональний міжвузовскій збірник наукових праць. – Випуск 6 (83). – Дніпропетровськ, 2012. – С. 23–28.

Розглянуто стан системи управління підприємства дитячого харчування. Доведено доцільність використання сучасних інформаційних систем для розв'язання різних задач на підприємстві. Розглянуто можливість використання теорії ігор для оперативного формування ціни продукції.

УДК 004.94:658.01

Осипенко В.В. **Експериментальне дослідження ефективності індуктивної технології системних інформаційно-аналітичних досліджень** // Системні технології. Регіональний міжвузовскій збірник наукових праць. – Випуск 6 (83). – Дніпропетровськ, 2012. – С. 29–37.

У статті розглянуто оригінальний експеримент та подано порівняльний аналіз ефективності різних технологій системних інформаційно-аналітичних досліджень (СІАД) пошукового спрямування. Експеримент поставлений як лабораторний магістерський практикум за спеціально розробленою програмою.

Бібл. 7, іл. 2, табл. 1.

УДК 004.032.26

Бодянський Є.В., Винокурова О.А., Мулеса П.П.**Навчання нейронної мережі Кохонена в задачах кластеризації-класифікації** // Системнітехнології. Регіональнийміжвузівський збірник науковихробіт. – Випуск 6 (83).– Дніпропетровськ, 2013. – С. 38–44.

В роботі запропоновано комбінований метод самонавчання-навчаннясамоорганізувальної мапи (SOM-LVQ), що дозволяє підвищити якість обробки інформації за умов перетинаючихся класів за рахунок раціонального вибору параметра кроку навчання і введення спеціальної процедури нечіткого вибору в процесі класифікації-кластеризації, який протікає як за наявності зовнішнього навчального сигналу («вчителя»), так і без нього. В якості міри подібності функцій сусідства і належності використовуються косинусоїдальні конструкції, що дозволяють забезпечити процесам самонавчання-навчання велику гнучкість і придати їм низку нових корисних властивостей.

Бібл. 3.

УДК 004.93'12+004.891.2

Дідик О.О. **Короткий оглядметодів виявленняаномалій**// Системні технології. Регіональний міжвузовскій збірник наукових праць. – Випуск 6 (83). – Дніпропетровськ, 2012. – С. 45–55.

У статті розглянута проблема виявлення аномалій та її характеристики в різних прикладних областях, виконана загальна постановка проблеми. Наведено короткий огляд існуючих методів виявлення аномалій, розглянуті їх переваги і недоліки. На підставі виконаного огляду зроблені висновки про стан справ у цій проблемній області.

Бібл. 36, табл. 1.

УДК 621.39

Гнатушенко В.В., Данладі Алі, Тутик В.А.**Моделювання процесівіаналізпродуктивностіпротоколумаршрутизаціїукорпоративнихмережах** // Системні технології. Регіональний міжвузівський збірник наукових праць. – Випуск 6 (83). – Дніпропетровськ, 2012. – С. 56–62.

Створено імітаційну модель корпоративної мережі MANET з маршрутизацією на основі протоколу GRP. Проілюстровано ефективність роботи протоколу для передачі мультимедійного трафіку.

Бібл. 12, іл. 5.

УДК004.021

Касіцький О.В., Бідюк П.І., Гожий О.П. **Застосування теорії максимізації математичного сподівання до розв'язання задачі розділення суміші гаусіан** // Системні технології. Регіональний міжвузовскій збірник наукових праць. – Випуск 6 (83). – Дніпропетровськ, 2012. – С. 63–71.

Робота присвячена дослідженню ефективних алгоритмів моделювання і прогнозуванняоптимізаційного типу. Наведено аналіз методу ExpectationMaximization, його переваги та недоліки. Представленопослідовність отримання і докладнийопис алгоритму. Наведено рекомендації щодо підбору параметрів для розробленого алгоритму. У роботі подано спосіб вирішення задачі розділення суміші гаусіан за допомогою ітеративного алгоритму на основі ЕМтеорії. На прикладі задачі розділення суміші двох незалежних гаусівських випадкових величин експериментально отримані оцінки якості функціонування методу на основі ЕМтеорії. Зроблено висновки щодо доцільності використання методу в різних умовах.

Бібл. 8, іл. 2, табл. 1.

UDC 519.7

Литвиненко В.І. **Застосування алгоритму негативного клонального відбору для класифікації раку з використанням ДНА-мікроарей даних** // Системні технології. Регіональний міжвузівський збірник наукових праць. – Випуск 6 (83). – Дніпропетровськ, 2012. – С. 72–90.

У роботі запропоновано метод класифікації , який грунтується на комбінації алгоритмів клонального і негативного відборів . Розроблений алгоритм призначений для розвязання задач бінарної класифікації при діагностиці раку за мікроаррей даними. Проведені експерименти показали високу точність класифікації розробленого алгоритму , в порівнянні з іншими алгоритмами класифікації.

Бібл. 31, іл. 6, табл. 5.

УДК 004:519.816

Огнєва О.Е, Рогальський Ф.Б. **Нечітка модель підтримки прийняття рішення при визначенні характеристик готового виробу** // Системні технології. Регіональнийміжвузовскійзбірникнауковихпраць. – Випуск 6 (83). – Дніпропетровськ, 2012. – С. 91–97.

Розглянута можливість використання нечіткої математики в методі аналізу ієрархій. Запропонований варіант метода аналізу ієрархій на основі лінгвістичних оцінок при визначенні характеристік готового виробу.

Бібл. 7 табл. 1, рис. 2

УДК 629.7.015.016

Самков О.В., Силков В.І. **Алгоритм розрахунку характеристик зліту з трампліну безпілотного летального апарату**// Системнітехнології. Регіональнийміжвузовскійзбірникнауковихпраць. – Випуск 6 (83). – Дніпропетровськ, 2012. – С. 98–104.

У статті представлена методика розрахунку кінематичних параметрів безпілотного літального апарату (БПЛА) при зльоті з трампліна. Проведено аналіз впливу цих параметрів на деякі характеристики безпілотного літального апарату.

Бібл.5, іл. 5.

УДК 669.18:681.5

Стовпченко І.В., Михальов О.І., Губинський М.В. **Ідентифікація процесу виклавки сталі у кисневому конвертері на основі MIMO-каскадної нейронної мережі**// Системні технології. Регіональний міжвузовскій збірник наукових праць. – Випуск 6 (83). – Дніпропетровськ, 2012. – С. 105–110.

Статтяприсвяченапроблемаідентифікаціїпараметрівтехнологічнихпроцесівметалургійноговиробництва, асаме: виплавцісталівкисневомуконвертері. Такожврамкахданоїстаттіформулюєтьсяіставитьсязадачаідентифікаціївихідниххімічниххарактеристикісталі, одержуваноїзакиснево-конверторногопроцесувиплавкисталі, звикористаннямгібридноїштучноїнейронноїмережіщомаєкаскаднуархітектуру, наводятьсяйаналізуютьсяотриманірезультатиідентифікації.

Бібл. 7, іл. 1, табл. 2.

УДК 621-83681.51

Зворыкин В.Б., СтанчицГ.Ю., Балакин В.Ф.**Настройка контура скорости при наличии упругой связи двигателя с механизмом**// Системнітехнології. Регіональнийміжвузовскійзбірникнауковихпраць. – Випуск 6 (83). – Дніпропетровськ, 2012. – С. 111–116.

В работе исследовано влияние упругой связи двигателя с механизмом на работу контура скорости в системе подчиненного регулирования. Для сравнительно небольших соотношений инерционных масс получено выражение для коэффициента усиления регулятора скорости, обеспечивающее наибольшее демпфирование колебаний в системе. Показано, что в этом случае вид переходного процесса определяется лишь коэффициентом соотношения инерционных масс.

Бібл. 2, іл. 5.

УДК 577.359

Чиженкова Р.А. **Математический анализ библиометрических показателей публикаций по нейрофизиологическим эффектам неионизирующей радиации разных видов (Medline-Internet)**// Системнітехнології. Регіональнийміжвузовскійзбірниknауковихпраць. – Випуск 6 (83). – Дніпропетровськ, 2012. – С. 3–11.

Представлены библиометрические данные по нейрофизиологическим публикациям относительно влияния неионизирующей радиации разных видов. Рассмотрены количественные характеристики публикаций выбранных направлений за 35-летний интервал времени (1966-2000 гг.). Проанализирована динамика чисел публикаций указанных типов. Сделано заключение о перспективах нейрофизиологических исследований действия неионизирующих излучений.

Библ. 16, табл. 7.

УДК 004:371.71

Вышемирская С.В. **Методологические основы построения информационных систем и технологий управления состоянием здоровья студента**// Системнітехнології. Регіональнийміжвузовскійзбірниknауковихпраць. – Випуск 6 (83). – Дніпропетровськ, 2012. – С. 12–22.

Рассмотрен методологический подход к процессу индивидуализации управления состоянием здоровья студентов. Подход использует анализ широкого круга показателей состояния здоровья с их последующим обобщением с целью формирования интегрального индекса оценивания уровня здоровья студента и разбиения множества студентов на группы, в которых применяются различные методики, комплексы упражнений и их интенсивность.

Библ. 8, илл. 4.

УДК 681.004.89:164.053

ВышемирскаяС.В.**Ценообразование как элемент системы управления предприятия детского питания** // Системні технології. Регіональний міжвузовскій збірник наукових праць. – Випуск 6 (83). – Дніпропетровськ, 2012. – С. 23–28.

Рассмотрено состояние системы управления предприятия детского питания. Доказана целесообразность использования современных информационных технологий для решения разных задач на предприятии. Рассмотрена возможность использования теории игр для оперативного формирования цены продукции.

Библ. 12, илл. 2.

УДК 004.94:658.01

Осипенко В.В. **Экспериментальное исследование эффективности индуктивной технологии системных инофрмационно-аналитических исследований** // Системні технології. Регіональний міжвузовскій збірник наукових праць. – Випуск 6 (83). – Дніпропетровськ, 2012. – С. 29–37.

В статье рассмотрен оригинальный эксперимент и представлен сравнительный анализ эффективности различных технологий системных информационно-аналитических исследований (СИАД) инновационного направления. Эксперимент поставлен как лабораторный магистерский практикум по специально разработанной программе.

Библ. 7, илл. 2, табл. 1.

УДК 004.032.26

Бодянский Е.В., Винокурова Е.А., Мулеса П.П. **Обучение нейронной сетиКохонена в задачах кластеризации-классификации** // Системні технології. Регіональний міжвузовскій збірник наукових праць. – Випуск 6 (83). – Дніпропетровськ, 2012. – С. 38–44.

Вработепредложенкомбинированныйметодсамообучения-обучениясамоорганизующейсякарты (SOM-LVQ), позволяющей повысить качество обработки информации в условиях пересекающихся классов за счет рационального выбора параметра шага обучения и введения специальной процедуры нечеткого выбора в процессе классификации-кластеризации, который протекает как при наличии внешнего обучающего сигнала («учителя»), так и без него. В качестве меры подобия функций соседства и принадлежности используются косинусоидальные конструкции, позволяющие обеспечить процессам самообучения-обучения большую гибкость и придать им ряд новых полезных свойств.

Библ. 3.

УДК 004.93'12+004.891.2

Дидык А.А. **Краткий обзор методов обнаружения аномалий** // Системні технології. Регіональний міжвузовскій збірник наукових праць. – Випуск 6 (83). – Дніпропетровськ, 2012. – С. 45–55.

В статье рассмотрена проблема обнаружения аномалий и ее характеристики в различных прикладных областях, выполнена общая постановка проблемы. Приведен краткий обзор существующих методов обнаружения аномалий, рассмотрены их достоинства и недостатки. На основании выполненного обзора сделаны выводы о состоянии дел в данной проблемной области.

Библ. 36, табл. 1.

УДК621.39

Гнатушенко В.В. Данлади Али, Тутык В.А.**Моделирование процессов и анализ производительности протокола маршрутизации в корпоративных сетях** // Системні технології. Регіональний міжвузовскій збірник наукових праць. – Випуск 6 (83). – Дніпропетровськ, 2012. – С. 56–62.

Создано имитационную модель корпоративной сети MANET с маршрутизацией на основе протокола GRP. Проиллюстрировано эффективность работы протокола для передачи мультимедийного трафика.

Библ.12, ил. 5.

УДК 004.021

Касицкий А.В., Бидюк П.И., Гожий О.П. **Применение теории максимизации математического ожидания к решению задачи разделения смеси гауссиан**// Системнітехнології. Регіональнийміжвузовскійзбірникнауковихпраць. – Випуск 6 (83). – Дніпропетровськ, 2012. – С. 63–71.

Работа посвящена исследованию эффективных алгоритмов моделирования и прогнозированияоптимизационного типа. Приведен анализ метода ExpectationMaximization, его преимущества и недостатки. Описан полный вывод и дано подробное описание алгоритма. Даны рекомендации для выбора параметров разработанного алгоритма. В работе рассмотрен способ решения задачи разделения смеси гауссиан с помощью итеративного

алгоритма на основе ЕМ теории. На примере решения задачи разделения смеси двух независимых гауссовых случайных величин экспериментально получены оценки качества функционирования метода на основе ЕМ теории. Представлены выводы относительно целесообразности использования рассмотренного метода в различных условиях.

Библ. 8, илл. 2, табл. 1.

УДК 519.7

Литвиненко В.І. **Применение алгоритма отрицательного клонального отбора для классификации рака с использованием данных ДНК- биочипов** // Системні технології. Регіональний міжвузівський збірник наукових праць. – Випуск 6 (63). – Дніпропетровськ, 2012. – С. 72–90.

Вработе предложен метод классификации, который основывается на комбинации алгоритмов клонального и отрицательного отборов. Разработанный алгоритм предназначен для решения задач бинарной классификации при диагностике рака по данным микрочипов. Проведенные эксперименты показали высокую точность классификации разработанного алгоритма, по сравнению с другими алгоритмами классификации.

Библ. 31, илл. 6, табл.5.

УДК 004:519.816

Огнева О.Е, Рогальский Ф.Б. **Нечеткая модель поддержки принятия решения при определении характеристик готового изделия** // Системні технології. Регіональнийміжвузовскійзбірникнауковихпраць. – Випуск 6 (83). – Дніпропетровськ, 2012. – С. 91–97.

Рассмотрена возможность использования нечеткой математики в методе анализа иерархий. Предложен вариант метода анализа иерархий на основе лингвистических оценок при определении характеристик готового изделия.

Бібл. 7, табл. 1, рис. 2

УДК 629.7.015.016

Самков А.В., Силков В.И. **Алгоритм расчета характеристик взлета с трамплина беспилотного летательного аппарата**// Системнітехнології. Регіональнийміжвузовскійзбірникнауковихпраць. – Випуск 6 (83). – Дніпропетровськ, 2012. – С. 98–104.

В статье представлена методика расчета кинематических параметров беспилотного летательного аппарата (БПЛА) при взлете с трамплина. Проведен анализ влияние этих параметров на некоторые характеристики беспилотного летательного аппарата

Библ.5, илл.5.

УДК 669.18:681.5

Стовпченко И.В., Михалев А.И., Губинский М.В. **ИдентификацияпроцессавыплавкисталивкислородномконверторенаосновеMIMO-каскаднойнейроннойсети**// Системнітехнології. Регіональнийміжвузовскійзбірникнауковихпраць. – Випуск 6 (83). – Дніпропетровськ, 2012. – С. 105–110.

Статья посвящена проблемам идентификации параметров технологических процессов, металлургического производства, а именно: выплавке стали в кислородном конвертере. Также в рамках данной статьи формулируется и ставится задача идентификации вы-

ходных химических характеристик стали, получаемой по кислородно-конверторному процессу её выплавки, с использованием гибридной искусственной нейронной сети с каскадной архитектурой, приводятся и анализируются полученные результаты идентификации.

Библ. 7, илл. 1, табл. 2.

УДК 621-83 681.51

Зворикін В.Б., Станчиц Г.Ю., Балакін В.Ф.**Настроювання контуру швидкості при наявності пружного зв'язку двигуна з механізмом** // Системні технології. Регіональний міжвузовскій збірник наукових праць. – Випуск 6 (83). – Дніпропетровськ, 2012. – С. 111–116.

У роботі досліджений вплив пружного зв'язку двигуна з механізмом на роботу контуру швидкості в системі підлеглого регулювання. Для порівняно невеликих співвідношень інерційних мас отримане вираження для коефіцієнта підсилення регулятора швидкості, що забезпечує найбільше демпфірування коливань у системі. Показано, щовцьомувипадкувидперехідногопроцесувизначаєтьсялишекоефіцієнтомспіввідношенняі нерційнихмас.

Библ. 2, илл. 5.

UDK 577.359

ChizhenkovaR.A.**Mathematical analysis of bibliometrical indices of published works on neurophysiolocal effects of non-ionized radiation of different kinds (medline-internet)**// System tecnologies. №6 (83). – Dnepropetrovsk, 2012. – P. 3–11.

Bibliometrical data on neurophysiological published works carried out with application of non-ionized radiation of different kinds (EMF, MW, MF and EF) are presented. Quantitative characteristics of published works of choose subdivisions during 35-year time interval (1966-2000) be considered. Dynamics of number of published works of these trends is analyzed. Conclusion about prospects of investigations of neurophysiological effects of non-ionizing radiation is done.

Bibl.16, tabl. 7.

UDK 004:371.71

Vyshemyrska S.V.**Methodological bases of creation of information systems and technologies of management of the state of health of the student**// System tecnologies. №6 (83). – Dnepropetrovsk, 2012. – P. 12–22.

Methodological approach to process of an individualization of management by a state of health of students is considered. Approach uses the analysis of a wide range of indicators of a state of health with their subsequent generalization for the purpose of formation of an integrated index of estimation of level of health of the student and splitting a great number of students into groups in which various techniques, complexes of exercises and their intensity are applied.

Bibl.8, il. 4.

UDK 681.004.89:164.053

VyshemyrskaS.V.**Automation of price forming management at child's food industry enterprises**// System tecnologies. №6 (83). – Dnepropetrovsk, 2012. – P. 23–28.

The state management system baby food company are presened. The expediency of the use of modern information systems for various tasks in the enterprise are proved. The possibility of using game theory to operational pricing of productsare presented.

Bibl.12, il. 2.

UDC 004.94:658.01

OsypenkoV.**Experimental study of efficiency of system-analytical research based on inductive technologies** // System tecnologies. №6 (83). – Dnepropetrovsk, 2012. – P. 29–37.

This article deals with the results of original experiment on comparative analysis of different technology effectiveness of system-information-analytical research (SIAR) in innovative direction. The experiment has been carried out as a Laboratory Practical Master Workshop in the framework of special designed program.

Bibl.7, il. 2, table 1.

UDC 004.032.26

BodyanskiyYe., MulesaP., Vynokurova O.**Kohonen neural network learning in the clustering-classification tasks**// System tecnologies. №6 (83). – Dnepropetrovsk, 2012. – P. 38–44.

In the paper, combined self-learning and learning method of self-organizing map (SOM-LVQ) is proposed. Such method allows to increase quality of information processing under condition of overlapping classes due to rational choice of learning rate parameter and introducing special procedure of fuzzy choice in the clustering-classification process, which occurs both with external learning signal ("supervised"), and without one ("unsupervised"). As similarity measure of neighborhood function or membership one, cosine structures are used, which allow to provide a high flexibility due to self-learning-learning process and to provide some new useful properties.

Bibl.3.

UDK 004.93'12+004.891.2

Didyk A.A. **Brief overview of anomaly detection methods** // System tecnologies. №6 (83). – Dnepropetrovsk, 2012. – P. 45–55.

In the paper problem of anomaly detection and its features in different application domains are considered, general statement of the problem is performed. Brief overview of existing anomaly detection methods is made, their advantages and disadvantages are discussed. Based on the overview conclusions about given problem domain state of art are made .

Bibl. 36, table 1.

UDK 621.39

Gnatushenko V.V. Danladi Ali, TutykV.A.**Simulation processes and performance analysis of routing protocol in corporate network** // System tecnologies. №6 (83). – Dnepropetrovsk, 2012. – P. 56–62.

A simulation model of corporate network MANET routing protocol based on the GRP. Illustrated the effectiveness of the protocol for transmitting multimedia traffic.

Bibl. 12, ill. 5.

UDK004.021

Kasitskyj O.V., Bidyuk P.I., Gozhyj O.P. **Application of expectation maximization theory to solving the problem of Gaussian mixture separation**// System tecnologies. №6 (83). – Dnepropetrovsk, 2012. – P. 63–71.

The paper is directed to the study of computationally effective algorithm of modeling and forecastingof optimization type. An analysis is given for the method of Expectation Maximization (EM algorithm), its advantages and disadvantages are considered. A derivation of the algorithm and its detailed description are provided. Some recommendations are given regarding parameter tuning for the algorithm developed. The work highlights a technique for separating the Gaussian mixture using iterative algorithm based on the EM-theory. The results of computing experiments for the EM-algorithm are presented using as example Gaussian mixture separation for two random variables. The conclusions are made regarding the possibilities of application the technique in different conditions.

Bibl.8, il. 2, table 1.

UDC 519.7

Lytvynenko V.I. **Application of Clonal Negative Algorithm to Cancer Classification with DNA-Microarray Data**// System tecnologies. №6 (83). – Dnepropetrovsk, 2012. – P. 72–90.

In the paper, a classification method is proposed. It is based on Combined Clonal Negative Selection Algorithm, which was originally designed for binary classification problems. The accuracy of developed algorithm was tested in an experimental way with the use of DNA-microarray data sets. The experiments confirmed that direction of changes introduced in developed algorithm improves its accuracy in comparison to other classification algorithms.

Bibl. 31, il. 6, tabl.5.

UDC 004:519.816

OgnievaO., Rogalsky F.**Fuzzy model for decision-making support in the determining of the characteristics of the finished product**// System tecnologies. №6 (83). – Dnepropetrovsk, 2012. – P. 91–97.

The possibility of the use of fuzzy mathematics in hierarchy analysis technique is considered. A variant of hierarchy analysis technique on the basis of linguistic estimates in the determining of the characteristics of the finished product is proposed.

Bibl. 7, il. 2, tabl. 5.

UDC629.7.015.016

SilkovV.I., SamkovA.V. **The algorithm for calculating the characteristics of the take-off from the springboard UAV**// System tecnologies. №6 (83). – Dnepropetrovsk, 2012. – P. 98–104.

The article presents the technique calculation of kinematical parameters the unmanned aerial vehicle (UAV) at take-off with springboard. The influence on these parameters some characteristics of the unmanned aerial vehicle is analyzed

Bibl.5, ill. 5.

UDK 669.18:681.5

StovpchenkoI.V., MikhalyovA.I., GubinskyM.V.**MIMO-based cascadeneuralnetwork identificationofoxygen convertersmeltingsteel**// System tecnologies. №6 (83). – Dnepropetrovsk, 2012. – P. 105–110.

The article deals with the problems of identification of parameters of technological processes, metallurgy, namely steel production in the basic oxygen furnace. Also as part of this article formulates and put to the task of identifying of chemical characteristics of steel using a hybrid artificial neural network with a cascade architecture.Data was processed for the oxygen-converter process of steel smelting. Given and analyzed the results of identification.

Bibl. 7, il. 1, tabl. 2.

UDK 621-83 681.51

ZvorykinV.B., StanchitsG.Y., BalakinV.F. **Modelling process of control of engine speed with flexible connection of the engine with the mechanism**// System tecnologies. №6 (83). – Dnepropetrovsk, 2012. – P. 111–116.

Questions of a speed control of the engine in system of the subordinated regulation in the presence of flexible connection of the engine with the mechanism are considered. Limits

of stability are defined. The regulator of the speed is calculated for rather small ratios of inertial masses (inertia coefficient less than 5.8). It provides the greatest damping of fluctuations in system. It is shown that in this case the type of transient is defined by only a coefficient of a ratio of inertial masses.

Bibl. 2, il. 5.

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