UDC 621.396

Ph.D. Sova O. (MITI)
Salnyk S. (MITI)
Salnyk V. (MITI)
Stempkovska Y. (MITI)

METHOD OF SELF-TRAINING FUZZY KNOWLEDGE BASES NODES INTELLECTUAL CONTROL SYSTEMS IN THE MANET

Сова О.Я., Сальник С.В., Сальник В.В., Стемпковська Я.А. Метод самонавчання нечітких баз знань вузлових інтелектуальних систем управління в мобільних радіомережах класу MANET. *У статті запропоновано метод самонавчання нечітких баз знань вузлових інтелектуальних систем управління в мобільних радіомережах класу MANET. Розглянуто особливості вузлових баз знань та методи отримання знань. Побудова запропонованого методу навчання ґрунтується на використанні нечіткої логіки та апарата нейронних мереж. Суть даного методу полягає в розподілі процесу самонавчання нечіткої бази знань вузлових інтелектуальних систем управління у відповідності з запропонованими кроками. Розробка методу дозволила на підставі поповнення бази знань в процесі функціонування мережі, приймати управлінські рішення відносно можливих подій в мобільній радіомережі.*

Сова О.Я., Сальник С.В., Сальник В.В., Стемпковская Я.А. Метод самообучения нечетких баз знаний узловых интеллектуальных систем управления в мобильных радиосетях класса MANET. *В статье предложен метод самообучения нечетких баз знаний узловых интеллектуальных систем управления в мобильных радиосетях класса MANET. Рассмотрены особенности узловых баз знаний и методы получения знаний. Построение предложенного метода обучения основывается на использовании нечеткой логики и аппарата нейронных сетей. Суть данного метода заключается в распределении процесса самообучения нечеткой базы знаний узловых интеллектуальных систем управления в соответствии с предложенными шагами. Разработка метода позволила на основании пополнение базы знаний в процессе функционирования сети, принимать управленческие решения относительно возможных событий в мобильной радиосети.*

O. Sova, S. Salnyk, V. Salnyk, Y. Stempkovska Method of self-training fuzzy knowledge bases nodes intellectual control systems in the MANET. *In article method self-training fuzzy knowledge bases nodes intellectual control system offers in mobile radio networks class MANET. Features knowledge bases nodes and methods receipt knowledge are considered. A construction an offer method studies is base on use fuzzy logic and vehicle neural networks. Essence this method consists in distribution process self-training fuzzy base knowledge nodes intellectual control system in accordance with offer steps. Development method allowed on basis addition knowledge bases in process functioning network, to accept administrative decisions in relation possible events in mobile radio network.*

Keywords: *treatment knowledge, base knowledge, intellectual control system, mobile radio network.*

Research actuality. Mobile radio networks (MR) or Mobile Ad – Hoc Network (MANET) [1] show a soba totality mobile devices (sites) that is located on locality by casual character equipped by radiomodule. Basic difference MR from classic radio networks is absence fixed network infrastructure and, as a result, fixed routes information that needs use fundamentally new going near control this class networks.

One such approaches there is use decentralizing control system (CS) in composition every mobile site [2], and also intellectualization processes control MR [3]. In [4] offer model intellectual control system (ICS) by site MR, a central place in that is extracted processes treatment knowledge about the state sites and situation that was folded in MR.

Administrative decisions that is accepted nodes ICS are based on an analysis and estimation great number heterogeneous parameters functioning sites and MR, to set quantitative dependence it is difficult or in general impossible (for example, quality maintenance certain type traffic and speed or direction moving sites) between that. In addition, through the frequent change operating MR (mobility sites results in frequent changes network topology) conditions service information about parameters functioning sites very quickly gets older, usually is inexact and insufficient for construction clear mathematical model functioning MR. On such conditions in basis ICS site MR must be fixed system knowledge about objects control, a mobile site can come forward as that, zone MR or MR on whole, and system knowledge must use such language representation knowledge, that would give to possibility adequately to recreate structure control objects and was characterized

sufficient formality and logic with aim construction compact, strict and clear system knowledge with possibility her self-training.

In this connection, an aim article, which consists in development method self-training fuzzy knowledge bases (KB) in intellectual control system MR class MANET, is actual on today's stage development wireless telecommunications.

Object consideration this article is a process treatment service information, receipt and representation knowledge about a situation in MR.

Article research is a method self-training fuzzy knowledge bases in ICS.

Analysis subject domain. Through dynamic and unforeseeable nature functioning radio networks class MANET control system behave by them to difficult distributed systems that are characterized weak formalization dependence entrance and initial variables, what the construction clear mathematical model such systems not always is possible from. The so-called intellectual methods and models that allow more adequately to display different aspects vagueness in the process control MR (related incompleteness information about her state) can be used in this case, in comparing analytical models and algorithms that are based on use of traditional methods design.

Functioning any ICS is base on converting service information into knowledge about a that or other subject domain, on basis that it will be accepted administrative decisions. As marked higher, ICS as a result collection and treatment information gets knowledge the site MR about the state other sites and situation that was folded in MR on whole. These knowledge show a soba totality information about every site MR, and also great number rules use of this information for the acceptance administrative decisions in MR. In practice operating knowledge in any ICS comes true KB.

Base knowledge ICS by site MR shows a soba special family database, that contains given in a certain form state information structured, mobile sites and MR whole, that is used by functional subsystems nodes ICS for acceptance administrative decisions on different levels model OSI.

By basic features nodes KB, that distinguish them from bases given is, :

– it is ability forming conclusions in automatic mode and acquisition new knowledge on basis obtained data from the environment functioning MR;

– it is ability KB to find contradictions that can arise up in it;

– it is ability KB to adapt oneself to the new operating mobile site or MR conditions, that like ability to "get experience" [5, 6].

In accordance with the above-mentioned determination, basic function nodes KB in relation to treatment knowledge about a situation in MR it is possible to divide into two constituents: representation knowledge and receipt knowledge (studies) [6, 7]. The first constituent is related to that nodes ICS shows a soba difficult technical system that needs hardware and programmatic representation intellectual functions. Second a constituent is related to the features functioning MR, that from one side require permanent updating KB and addition to it new rules, and on the other hand eliminate a man from process control nodes and network resources.

On method studies methods receipt knowledge are divided into:

1. Methods studies with a teacher where for every precedent a "situation - necessary decision" (educational selection) is force set. The examples methods studies from a teacher are:

– a method correction error is a method studies perceptron neural network, at that weight connection does not change that pore, while current reaction perceptron remains correct. At appearance wrong reaction weight changes on unit, and a sign (+/-) is determined by opposite sign error [8];

– a method reverse distribution error is a method studies Multi-layer perceptron neural network, that consists in distribution signals error from the return network to her entrances, in direction reverse to direct distribution signals in ordinary mode operations network [9]. This method a method gradient lowering, that envisages change weight transneuronal connections proportionally measure their influence on a difference between model and experimental initial variable values, is basis [10].

2. Methods studies without a teacher, id est method machine studies, during that investigated system spontaneously studies to execute a task, without interference from the side of experimenter. As a rule this method studies is suitable for tasks there are well-known descriptions great numbers objects (educational selections) in that, and it is necessary to educe internal intercommunications, dependences and conformities to law, that exist between objects.

Coming from indicated, for ICS MR it is expedient to use methods studies class MANET with a teacher on stage construction network, and farther for self-training network it is necessary to use methods studies KB without a teacher, basic line that are independence and capacity for self-organization.

Thus, the fuzzy design process functioning nodes ICS envisages description causation between the entrance and initial variables of that or other subsystem of nodes ICS, that characterize certain dependence on each levels model of OSI by means fuzzy KB. It is necessary to notice that fuzzy KB will realize these copulas a human language with the use of theory fuzzy sets and linguistic variables, that allows to build dependences between physically separate entrance and initial sizes during the design of nodes ICS. Taking into account inaccuracy information and incompleteness knowledge about a situation in MR, that is caused by complication MR as systems and by dynamic nature of the operation elements, in [4] the use vehicle fuzzy sets and neural networks (NN) offers for construction KB nodes ICS and her self-training in process her further functioning.

In addressing issues of self-fuzzy KB, built using neural networks are devoted D.O. Hebb, A.P. Karpenko, V.V. Borisov, A.K. Jane. However, part of these works investigates the question support and making decision persons that make decision at different family economic, biological or social systems, and other part - does not take into account features functioning MR class MANET. In this connection in this article method self-training fuzzy BK is offered in ICS, that will allow to carry out the process addition new knowledge KB nodes ICS by means application neuro-fuzzy logic.

NN show a soba the system artificial neurons united and interactive inter se. At presence connection neurons in a large network of interaction which is managed, such networks are able to execute difficult tasks. NN have ability to conduct studies, in consequence what NN able find out difficult dependences between entrance and initial data, and also conduct clusterization entrance characters to the taught list parameters.

Research NN is considered presently to one the most perspective directions in industry of artificial intelligence. It is possible to take to the features NN [11]: the simple functional cursored element is a neuron; the far neurons takes part in the process treatment information; one neuron is related to plenty of other neurons; the scales connections change between neurons; massed parallelism treatment information.

From the formal point view NN shows a soba universal model-approximation as a count, the main line of that is the use connections different weight between neurons as to the tool for memorizing information. Treatment information NN is conducted simultaneously by plenty the cursored elements, due to what they are proof to the disrepairs and apt at rapid calculations. To other advantages NN it is possible to take the small volumes of memory, necessary for storage neurons, high adaptivity, and also capacity for working of fuzzy and incomplete information, that allows to apply NN in any subject domain, including at the decision tasks prognostication difficult processes.

Fuzzy logic (FL), among all well-known tools design is based on fuzzy sets [12,13] but allows to carry out mathematical formalization logical-linguistic information, that is used at description of difficult nonlinear objects. As a rule, the design of such objects is taken to the construction of fuzzy KB, that incarnate in itself expert knowledge about an object as linguistic expressions IF-THEN, that attribute to advantages.

Thus, through the features functioning MR (frequent changes topology MR, unforeseeable character their functioning, and others like that) to overcome the fuzzy knowledge about the state

sites MR and radio network on the whole very difficult, as on the stage planning so on stage operative control MR. On such conditions the most expedient and actual going near the construction nodes ICS is the use vehicle fuzzy sets and NN. It is explained by that marked a mathematical vehicle gives an opportunity to operate with the lexical categories estimations, perception and ways thinking expert, that it is especially important on the stage planning nodes ICS, thus considerably will facilitate the initial studies nodes ICS, so as a vehicle FL, that operates linguistic variables, allows most exactly to realize machine interpretation knowledge experts. At the same time, application methods NN for the construction rules fuzzy product will provide ability nodes ICS to study on own experience.

Assumption: examine process functioning site real-time, there is ICS in composition that built on technology intellectual agents. In composition ICS is KB, that is built on technology NN.

Preset parameter MR: have a great number entrance variables x_n.

Population customers to the method self-training knowledge bases ICS: {Bq = {B1, B2, B3, B4}: work is in the conditions decentralizing control; minimum work-load network by service information; possibility co-operating is with different levels model OSI.

It is necessary: to work out method self-training fuzzy KB ICS in MR class MANET, using fuzzy logic and neural networks for this purpose. To attain this aim it is necessary for the least steps.

A method self-training fuzzy knowledge bases is in ICS.

Quitting a necessity to conduct self-training NN without a teacher and feature functioning MR class MANET will define the row requirements to the method: studies without a teacher; decision tasks of classification and cauterizations; realization adaptation network is for work at fuzzy network activity; presence in the network feed-backs; there is realization studies real-time.

Quitting requirements and given the characteristics neuro-fuzzy for the construction knowledge bases ICS for basis there was a select method studies of Hebb [14]. In the method Hebb a process studies is exceptionally a local process that embraces two nearby neurons and synapse; there is not a requirement in a global feed-back for development neuron formations.

A new method self-training fuzzy knowledge bases nodes intellectual control system in the MANET.

For the decision of the put task the new method of self-training of fuzzy knowledge bases nodes intellectual control system is offered in mobile radio networks class MANET, where at a robot KB, a neuron gets the great number entrance signals simultaneously.

Every entrance has own synaptic weight that influences on her and needed for the function of summator. Weight shows a soba measure importance entrance connections and designs behavior synapses. The scales ponderable entrance increase and scales unimportant entrances diminish superfluously, that determines intensity entrance signal. Scales change in accordance with trainees examples and rules KB [10,23].

The method studies fuzzy KB ICS consists in the calculation previous measuring returns for determination changes weight by next rule:

$$\omega_{ij}(t) = \omega_{ij}(t-1) + \alpha \cdot y_i^{(n-1)} \cdot y_j^{(n)}, \quad (1)$$

where $y_i^{(n-1)}$ – initial value of neuron i layer $n-1$, y_j^n – initial value of neuron j layer n; $\omega_{ij}(t)$ – weigher coefficient of synapse from to the neuron i to the neuron j in the moment of time t, $\omega_{ij}(t-1)$ – weigher coefficients of synapse that connects a neuron, on iterations t and $t-1$ accordingly; α – coefficient of speed of studies. Here and farther under n it is considered the arbitrary layer of neural network. At studies on this method copulas increase between the excited neurons.

In a differential method the cycle serve of educational characters proceeds until then, while the initial values NN are not stabilized with the set exactness. Such network is able to summarize identical offenses that attribute to one class of events. For presentation results studies network in a

comfortable form it can complement a network one layer and teach this layer on the method of reverse distribution of error.

At studies after this method copulas increase between the excited neurons.

Taking into account the objective function making decision neuro-fuzzy ICS it maybe to present as follows:

$$U^*(t) = \arg \underset{U_ф(t), U_м(t) \in \Omega}{opt} Y(t)(X(t), U_ф(t), U_м(t)), \forall\ Z_{ij} = 1,\ i, j \in N,\ i \neq j \quad (2)$$

$$w_g = f_w\left(x_1^*,\ x_2^*, ...,\ x_g^*\right),\ g = \overline{1, G}, \quad (3)$$

where $X^* = \left\langle x_1^*,\ x_2^*, ...,\ x_g^* \right\rangle$ – vector fixed values variables, that act on the entrance nodes ICS; w_g – initial variable value.

The task making decision from providing safety sites consists in that on the basis of information about the vector of entrances X^* to define a return $w_g \in Y$. For the decision this task the system fuzzy rules (SFR) is formed as:

Thus for the studies knowledge bases ICS networks class MANET expedient will be the use differential method that consists next steps.

On the first step that has the name initializing, casual values are appropriated all weigher coefficients. At forming of rulebase taking into account the unforecast processes in MR, at casual influences and in the conditions dynamic and fuzzy it is necessary to use the vehicle fuzzy sets and NN.

On the basis analysis subject domain, functional features application neuro-fuzzy networks, characteristic features MR and requirements to the construction method studies KB, the fuzzy NN Takagi-Sugeno-Kang, that gives the least error of studies and the best exactness prognostication, was select.

A network executes the fuzzy guiding Sugeno out use N variables x_j but m rules:

$$\Pi_k : If x_1 \in A_1^{(k)}\ and\ x_2 \in A_2^{(k)}\ and ...and\ x \in A_N^{(k)},\ \text{then}\ y_k = w_0^k + \sum_{j=1}^{N} w_j^k x_j \quad (4)$$

where A_j^k – fuzzy therm it must belong to that j- but entrance variable, to activate k- governed, w_j^k – weigher coefficient, $k = 1, 2, ..., m$.

In a general view great number the formed rules fuzzy product, that display dependence, it is possible to present following character:

IF $\left(x_1 = a_1^{11}\right)$ AND $\left(x_2 = a_2^{11}\right)$ AND … AND $\left(x_n = a_N^{11}\right)$

OR $\left(x_1 = a_1^{12}\right)$ AND $\left(x_2 = a_2^{12}\right)$ AND... AND $\left(x_n = a_N^{12}\right)$

OR… $\left(x_1 = a_1^{1k_1}\right)$ AND $\left(x_2 = a_2^{1k_1}\right)$ AND... AND $\left(x_n = a_N^{1k_1}\right)$

THEN $w_g = d_1^1$,

where d_g^h ($g = \overline{1, G}, h = \overline{1, H}$) – it is a linguistic estimation initial variable w, what is certain from the great number therm possible decisions D; a_n^{mk} – linguistic estimation entrance variable x_n y k – to the row m - to disjunction that gets out from the corresponding great number therm A_n, $n = \overline{1, N}$; H – amount therms that is used for the linguistic estimation initial variable w_g.

Thus initial variable value w_g in the end it is determined as some material number.

In accordance with the values linguistic therms, that display the decision neuro-fuzzy ICS between the sites MR, in-process two groups SFR offer: governed, that consist types aberrant behavior and rules that consist normal behavior. Thus, each groups rules must envisage two cases construction control system : during that information gathers basis clusterization and classification incoming traffic, (id est $i = a$ but $j = g$, $i, j, a, g \in N$) but when on the basis characteristic therms

suggestion will be given in relation to an administrative decision in relation to every separate encroachment that consists of h, $h = \overline{1,\ N-1}$ encroachments.

With the aim providing plenitude and indisputability KB it is expedient to break up space entrance and initial variables in accordance with a minimum or maximal every variable value. A corresponding great number is from linguistic values { subzero, middle, high} or more detailed, there will be depend from a certain task that decides.

The algorithm Sugeno will be used farther, is characterized that the presence outputs rules d_g^h , what are set by a linear function from entrances, for example:

$$\bigcup_{k=1}^{k_m}\left[\bigcap_{n=1}^{N}(x_n = a_n^{mk})\right] \to w_g = b_{g0} + \sum_{n=1}^{N}(b_{gn}\cdot x_n),\ g = \overline{1,G}, \tag{5}$$

where b_{g0} but b_{gn} – some coefficients

Id est, governed in the base Sugeno are family switches from one linear law "entrance-return" on other linear law. The feature algorithm fuzzy output Sugeno consists in the use him in that case, when to get such knowledge expert it not maybe. In this connection, for the construction fuzzy KB nodes ICS the use KB Sugeno is offered [13]. Realization fuzzy conclusion nodes ICS, in an algorithm shows a soba the second step, comes that true in accordance with the next stages [15]:

1. Stage - fazifikatsiya, as a result implementation this procedure values functions belonging are worked out for entrance variables that consists in establishment accordance between the certain value the separate entrance variable system fuzzy conclusion and value S_n^{mk}, what displays the degree truth subcondition rule on the basis value function belonging corresponding to it therm entrance linguistic variable:

$$S_n^{mk} = \mu_n^m(\overline{x_n}), \tag{6}$$

where $\overline{x_n}$ – vector values entrance variables the system fuzzy conclusion; $\mu_n^m(\overline{x_n})$ – function belonging m - therm.

2. Stage – aggregating – there is determination degree truth terms on that S^{hk}, $h = \overline{1,H}$ after each rules the system fuzzy conclusion on the basis well-known values truth subterms S_n^{mk}, what enter to him. If the condition rule is set in form fuzzy linguistic expression kind $x_1 = a_1^m$, $m = \overline{1,\ M}$, the stage their aggregating abandons the degree truth without a change. If the condition rule consists a few subterms, the degree truth for such rule is determined [16]:

$$S^{hk} = \min_n S_n^{mk}; \tag{7}$$

$$S^{hk} = \max_n S_n^{mk}, \tag{8}$$

where, expression (8) displays logical conjunction or logical "AND" fuzzy subterms rule (4), and expression (9) - logical disjunction or logical "OR" governed (4). Those rules, degree truth that not zero, are considered active and used for further calculations.

On this stage, the great number rules is worked over with their further aggregating in a finishing decision. At planning devices with fuzzy logic it is important to provide possibilities their adaptation to the changes environment the method studies rulebases that is built on the basis experience and knowledge experts, created models actions operator and method studies. In turn studies consist in the adaptive selection parameters fuzzy sets and automatic generuting rules fuzzy inferencing.

3. Stage – activating – envisages determination values function belonging each subconclusions for the weekend linguistic variables, that is examined. A calculation comes true after a formula:

$$\mu^{hk}(\overline{w_g}) = \min_h\left\{Z_g^h,\ \mu_g^h(\overline{w_g})\right\}, \tag{9}$$

where $\mu_g^h(\overline{w_g})$ – function of belonging h - therm of initial variable $\overline{w_g}$; Z_g^h – degree truth each of subconclusions, that settles accounts after a formula:

$$Z_g^h = S^{hk} \cdot F^k, \tag{10}$$

where F^k – it is a weigher coefficient rule.

4. Stage – accumulation – envisages an association and accumulation with the use triggerable operation of max- disjunction [15, 17] all degrees truth subconclusions for the receipt function belonging each weekend variable:

$$\mu_g^*(\overline{w_g}) = \bigcup_{k=1}^{k_M} \bigcup_{h=1}^{H} \mu^{hk}(\overline{w_g}). \tag{11}$$

5. Stage – defuzzyfication, consists in that on the basis results accumulation all weekend linguistic variables clear (quantitative) values turn out each weekend variable, that can be used by the subsystems site (what is external in relation to the system fuzzy output nodes ICS) in the process its functioning. In accordance with the algorithm Sugeno [18], for defuzzyfication the modified variant is used in the form method centre gravity for one point great numbers:

$$w_g = \frac{\sum_{h=1}^{H} Z_g^h \cdot d_g^h}{\sum_{h=1}^{H} Z_g^h}, \tag{12}$$

where w_g – a result of defuzzyfication is as a clear initial variable value; H – common amount of active rules fuzzy to the products, there is an initial linguistic variable in the suboutputs that d_g^h.

On the third step on the entrances of network entrance character is given, and the signals of excitation spread for all to the layers accordingly principles classic livestreaming networks [19], id est for each the self-weighted sum its entrances, to that an activating (transmission) function is used to the neuron, settles accounts a neuron, as a result of what get him initial value y_i^n, where $i = 0...m_{j-1}$, m_j – a number of neurons is in a layer j; $n = 0...N-1$, and N – number of layers of network.

On a fourth step, so as in (1) a – coefficient of speed of studies i - neuron from the radius of studies in k - loop of studies. The scales of neurons that are outside the radius studies do not change. Coefficient speed studies a divided into two parts: function neighbourhood $\eta_i(d,k)$ but function speed of studies $a(k)$:

$$a = \eta_i \cdot (d,k) \cdot a(k). \tag{13}$$

As a function of neighbourhood Gaussian function is used :

$$\eta_i(d,k) = e^{\frac{d_i}{2\sigma(k)}}, \tag{14}$$

where d_i – distance between i – by a neuron and "neuron-winner". Thus $\sigma(k)$ – function arcwise running back from to the number of cycle of studies.

Function speed studies $a(k)$ presents by a soba running back from to the number cycle studies [20], but used as arcwise or back-proportional from to the number cycle studies of kind:

$$a(k) = \frac{A}{k+B}, \tag{15}$$

where A and B it is constants. The use of this function results in a volume, that all vectors from a trainees selection bring in approximately equal payment in the result studies.

Studies will consist of two stages [21]:

– on initial the large value of speed studies and radius studies are elected, that allows to locate the vectors neurons in accordance with a distributive reception in an elector.

– on final more exact tuning weight is conducted, when value parameters speed studies far less initial.

Studies will proceed until error network at p entrance vectors will not become the least size (ω_j –vector of weight „ neuron-winner ”) [22].

$$E = \frac{1}{p}\sum_{i=1}^{p}\left\|x_i - \omega_j\right\|^2 . \quad (16)$$

On a fifth step, on the basis of the got initial values neurons on a formula (1) the change weigher coefficients comes true.

On a sixth step there is verification accordance entrance values to the pulled out requirements. In case falling short initial values goes back to the second step until then while. This step takes place until then while initial value NN, not stabilized in maximal accordance.

CONCLUSIONS

Thus, in article first method self-training fuzzy KB offers in ICS MR to the class MANET. Essence method consists in the studies KB in ICS at application fuzzy logic and vehicle neural networks. In a method it offers to conduct the studies knowledge bases ICS without a teacher. This method allows to fill up the base knowledge in process functioning MR, that in turn, allows ICS real-time to accept administrative decisions in relation to possible events at MR or influences on a network.

During further researches there will be the conducted estimation efficiency new method self-training fuzzy knowledge bases nodes intellectual control system in the mobile radio networks class MANET, and also the method self-training knowledge bases nodes intellectual control system is worked out in the mobile radio networks class MANET.

LITERATURE

1. Elmasry G.F. Tactical wireless communication and networks: design concepts and challenges // – UK: John Wiley and Sons Ltd, 2012. – 328 p.

2. Romanyuk V.A. The system architecture of operational control tactical radio networks // Proceedings of Viti "KPI". – 2009. – № 3. – P. 70 – 76.

3. Zhuk P., Romanyuk V., Sova O., Bunin S. Intellectual Mobile Ad Hoc Networks // In Proc. of International Conference Modern Problems of Radio Engineering, Telecommunications and Computer Science (TCSET 2012), Lviv, 2012. – p. 238.

4. Romanyuk V.A. Sova O.J., P.V. Beetle, A. Romaniuk The concept of building a hierarchical control systems yntellektualnыh tactical MANET // radio networks class collections tezysov dokladov and stuplenyy participants XXII Mezhdunarodnoy Krimskaya conference ["microwave technics and technologies telekommunykatsyonnые"] (KrыMyKo). – Sevastopol, 2012. – S. 265.

5. Romanyuk VA Target features operational control of tactical radio networks // Proceedings of Viti "KPI". – 2012. – № 1. – P. 109 – 117.

6. Bushuev SN, Osadchy AS, Frolov V. Theoretical Principles of Creation is information–technical systems // – St. Petersburg .: YOU, 1998. – 404 p.

7. Gavrilova TA, Horoshevskyy VF Bazы known yntellektualnыh systems // textbook for high schools – St. Petersburg .: Peter, 2000. – 384 p.

8. Sova O.J/, Romanyuk V.A., beetle PV The concept of hierarchical intelligent building control systems Mobile Broadband military // Proceedings of Viti "KPI". – 2010. – № 2. – S. 121 – 130.

9. Learning Mashynnoe [Electronic resource] // Wikipedia. – Last Updated 01.14.2014 page. – Access mode:
https://ru.wikipedia.org/wiki/Машинное обучение.

10. Komashynskyy VI, Smirnov DA Neural network and s use in control systems and communication // – M .: hotline Telecom, 2002. – 94 p.

11. Wang L., Cheng L., Zhao G .. Machine Learning for Human Motion Analysis // – IGI Global, 2009. – 318 p.

12. A. Starikov neural network-mathematical apparatus [Electronic resource] // – Base Group Labs. – Access:

http://www.basegroup.ru/library/analysis/neural/math.

13. Shtovba SD Introduction to Theories and nechetkyh multitude nechetkuyu logic // – Vinnitsa: Continent-Comm. – 2003. – 198 p.

14. JP Beshlebnova Nechetkye models and methods in yntellektualnyh systems //.– K., "Word", 2008.– 333 p.

15. Witten I.H., Frank E. Mark A Ian H. Hall Data Mining: Practical Machine Learning Tools and Techniques: 3rd Edition // Witten ,. – Morgan Kaufmann, 2011. – 664 p.

16. H. Ueno and presentation of knowledge // Using pod.red. H.Uэno: Per. with Japan. – M .: Mir, 1989. – 220 p.

17. Makarov IM, blueberries VM Manko SV Romanov, MP Artificial Intelligence .// yntellektualnыe and control system // Oddzial inform. technology and vыchyslyt. of Sciences. – M .: Nauka, 2006. – 333 p.

18. Uossermen F. Neyrokompyuternaya technics: Theory and Practice // –M .: Mir, 1992. –184 with.

19. Lakshmi C.J., Martin N.M. Fusion of Neural Networks, Fuzzy Systems and Genetic Algorithms: Industrial Applications // – CRC Press, 1998. – 368 p.

20. S. Haykyn neural network // For the full rate [Per. with English. NN Kussul, AJ Shelestova. 2nd ed., Corr.]. – M .: Publishing. Home Williams, 2008. – 1103 p.

21. F. Rosenblatt Principles neyrodynamyky. Pertseptronы Theory and brain mechanisms // – M .: Mir, 1965. – 480 p.

22. Rutkovskaya D. Pylynskyy M., L. Rutkovskyy neural network, henetycheskye algorithms and systems nechetkye // – 2nd ed. – M: hotline Telecom, 2008. – 452 p.

23. Redko VG, GA Beshlebnova The formative model of adaptive behavior avtonomnыh ahentov // "Yntehryrovannыe model and myahkye vыchyslenyya in yskusstvennom yntellekte." Collections of Labor and V–Mezhdunarodnoy scientific conference. T. 1. N .: Fyzmatlyt, 2009. S. 70 – 79.