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METHOD OF ARRANGEMENTS OF EXPLORATION OBJECTS DURING THE EXPLORATION OF DATA

Abstract. The effectiveness of the forces and devices of intelligence operations is determined by the number of intelligence objects discovered and the quality of intelligence obtained about them. In turn, these indicators depend on the degree of conformity of the results of the decision of the task of planning the use of forces and means of exploration, in accordance with the conditions of the operational situation. However, when the number of multiple reconnaissance objects is large, the existing reconciliation approach does not allow for adaptive, rational planning for the use of reconnaissance assets. The article proposes the solution of the actual scientific task of developing a scientific-methodical apparatus of the ranking of objects of intelligence in the assessment of the operational situation, in the interests of intelligence planning. The rank of an exploration object is calculated based on its qualitative and quantitative characteristics. The functional dependence of the rank of the intelligence object on its intelligence value and its identification with the operational environment is realized by a fuzzy artificial neural network. In the course of the research, the authors used methods of artificial intelligence, theories of information processing, the method of analysis of hierarchies and general scientific methods of analysis and synthesis. The result of the ranking procedure is the introduction of a plurality of scheduled intelligence objects into the order. Arranging multiple intelligence objects allows you to formalize and solve the quasi-optimal distribution of intelligence assets and forces. The practical significance of the study conducted by the authors is that the proposed method is appropriate to use in the development of software for decision support systems that are intended to solve the intelligence tasks of military forces of the national security and defense sector.

Keywords: ranking, intelligence; intelligence planning; fuzzy sets; artificial neural networks; use of intelligence.

Introduction

The effectiveness of the forces and devices of intelligence is determined by the number of intelligence objects (IO) that were discovered and the quality of intelligence that they have obtained.

In turn, these indicators depend on the degree of conformity of the results of the solution of the task of planning the use of forces and devices of intelligence (FDI), in accordance with the conditions of the operational situation.

The key operation that is used to solve the reconnaissance planning task is the operation of detecting and identifying intelligence objects.

Objects that are identified by intelligence are characterized by a variety of qualitative and quantitative characteristics that have different intelligence values and, accordingly, varying degrees of importance.

Thus, the detection and recognition of intelligence objects requires the implementation of a credible, scientifically sound mapping of the many characteristics of intelligence objects H on the set of real numbers that characterize the rank of the k-th intelligence object

$$w_k : f(h_k) \to w_k,$$

where $h_k = \{h_1, ..., h_n\}, h_i \in H$.

The presentation of the image $f(h_k) \to w_k$ analytically in the context of the problem under consideration does not exist today. The techniques currently available implement mapping $f(h_k) \to w_k$ using a mathematical apparatus that is based on expert judgment, rationing or multiplicative (additive) convolution methods.

The application of the specified group of methods to the implementation of the procedure of ranking of objects of intelligence is conditioned by the presence of the following disadvantages in the existing methodology of planning the use of forces and devices of intelligence:

the lack of automation of the planning procedure for the use of reconnaissance tools in the given conditions of the operational environment;

the analysis of the results of the implementation of the plan for the use of forces and devices of exploration is not formalized and subjective;

accounting of the consequences of the results of the use of intelligence during the next planning of the use of forces and devices of intelligence is missing.

Thus, in situations where the number of multiple reconnaissance objects is large, the existing approach of reconciling reconnaissance objects does not allow for adaptive, rational planning for the use of intelligence.

Setting the task of the research. The decomposition of the task of planning the use of forces and means of exploration into a number of partial tasks and their relationship is presented in Fig. 1.

In a formalized form, the task of ranking IO in the context of solving the problems of planning the use of FDI can be represented in the following form:

$$r^* = \arg\max_{\pi \in G} \left(F\left(\pi[a, r]\right)\right), \quad (1)$$

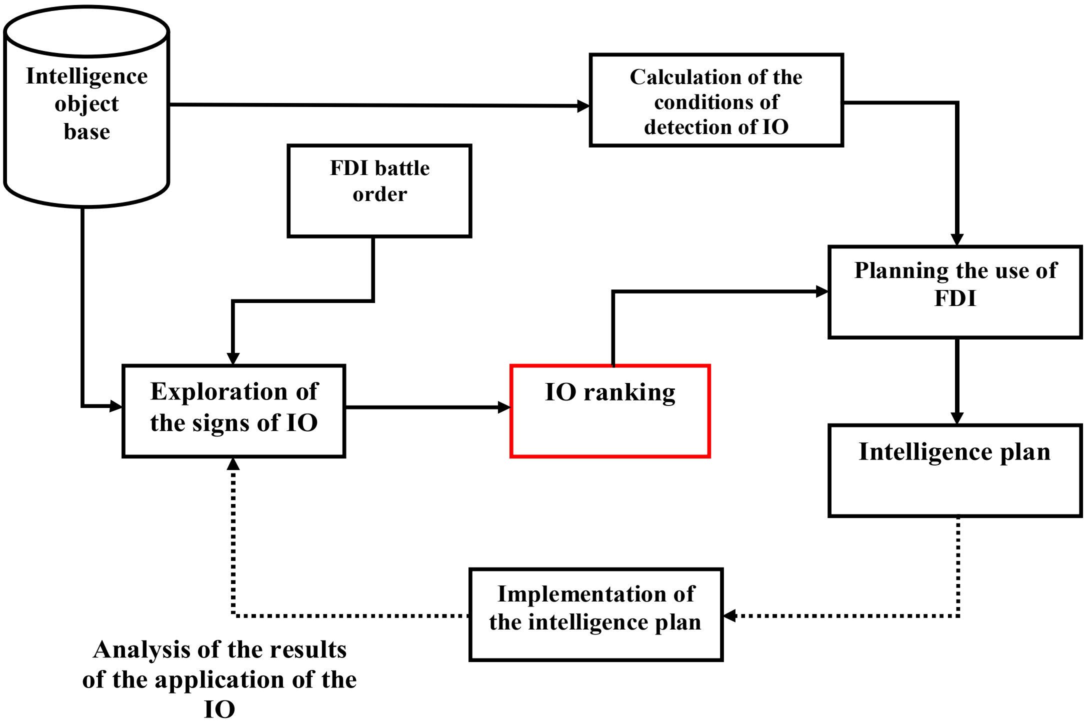

Fig. 1. Structural and logical scheme of solving the problem of planning the application of FDI

where $F\left(\pi\left[a,r\right]\right)$ is the objective function of an indicator of the efficiency of functioning of FDI;

$\pi\left[a,r\right]$ is the plan for the application of FDI while using the appropriate scheduling algorithm a to the IO ranking list r;

a is the planning algorithm for the use of FDI;

r is the ranked IO list consisting of n elements, meaning of the i-th element r;

characterizes the rank of the i-th IO among n objects;

G is the set of constraints that are imposed on the scheduling procedure in a given operational environment.

As the value of the objective function

$$F\left(\pi\left[a,r\right]\right)$$

of the expression (1), in this paper we consider the total rank of the IO, during the implementation of the plan π. The effectiveness of the intelligence plan π of the implementation process, it is suggested to evaluate according to the following criterion.

$$\left(\sum_{i=1}^{n}\left(k_i \cdot r_i\right)\Big/n\right) \rightarrow \min; \qquad (2)$$

$$\begin{cases} k_i = 0, & \text{if } i\text{- th IO don't take into account;} \\ k_i = 1, & \text{if } i\text{- th OP take into account.} \end{cases}$$

where k_i is the binary coefficient characterizing the fact of consideration of the i-th IO during the implementation of the plan π; r_i is the rank of the i-th IO that is calculated according to the proposed method; n is the number of IOs that are taken into account while planning.

Analysis of the recent works. In the works [1, 2], the author proposes a method for determining the rational number of intelligence features to determine their membership in the objects of intelligence.

The authors of the works [3-5] proposed a scientific and methodological apparatus for determining the state of exploration objects. The proposed approaches require considerable computing resources.

The analysis of the works [6-8] states that the task of estimating the rank of IO is similar to the classical problem of classification (recognition) of images. The most common and tried and tested mathematical apparatus used to solve similar problems today is the mathematical apparatus of artificial neural networks. However, the use of the classical neural network to solve the problem of ranking a large number of IO is associated with the problem of training artificial neural networks and involves the presence of a certain training sample. Accordingly, to implement this procedure requires a set R that includes as its elements a pair of values and many characteristics. The process of generating a set R of mandatory data consistency conditions is a complex, time-consuming process, due to the inability to characterize a complex multicriteria object with a single numerical value.

A reliable solution to this problem can be ensured by proposing to characterize the IO as an object capable of belonging to three classes – "important", "middle", "unimportant" – with a specific function of belonging to each class. The formalization of this procedure is conveniently carried out using the mathematical apparatus of the theory of fuzzy sets.

Thus, the purpose of the article is to develop a method of ranking intelligence objects in the processing of intelligence when conducting intelligence using a mathematical apparatus of fuzzy artificial neural networks, which will allow to take into account the consequences of the use of intelligence tools to observe the IO in the planning of intelligence with the application of the principles of ranking taking into account dynamic changes in the operational environment.

Presentation of the main material

The IO ranking method using a fuzzy artificial neural network consists of sequentially performing the following steps.

Step 1. The architecture of an artificial neural network, in the form of a graph $G=(X,V),$, is formed, where X is the set of vertices of an artificial neural network, V is the set of connections between the elements of the set X. The weights of connections w_{ij} between network neurons are activated by random values in the range of possible values from -0.5 to 0.5. The coefficient value is calculated w_{ij}^*:

$$w_{ij}^* = \sqrt{\sum_{j=1}^{n} w_{ij}^2}, \quad (3)$$

where n is the number of vertices in the i-th layer of a fuzzy neural network.

The connection weights between the neurons of the adjacent layers are re-initialized:

$$w_{ij} = \beta \cdot w_{ij} / w_{ij}^*, \quad (4)$$

where β is the scaling factor that is calculated according to the expression

$$\beta = 0,7 \cdot p^{1/n}, \quad (5)$$

where P is the number of neurons in the inner layers of the artificial neural network, n is the number of layer neurons. For each vertex of an artificial neural network, the offset $w_{0j}, w_{0j} \in [-\beta, \beta]$. is randomly determined.

Step 2. The sampled learning objects, the vector, are fed to the input of the artificial neural network

$$x = (x_1, x_2, x_3, x_4, x_5, x_6),$$

as well as the corresponding standards of the results of their processing by belonging to the classes of the set C of the vector d.

Step 3. Perform the phasing procedure of the first layer of an artificial neural network. This procedure consists in determination of the membership function $\mu(x|c_j)$ of the IO characteristics $x_1, x_2, x_3, x_4, x_5, x_6$ to classes that are defined on the set

$$C - \mu(x|c_j), j \in \overline{1,|C|}.$$

The fuzzy set membership function is a generalized indicator function of the classical set. The implementation of this procedure involves two steps. The first stage is the calculation of class centers V_{ij} of the elements of the set C for each IO intelligence feature.

$$V_{ij}^S = \sum_{x \in X_i} \left(\mu^S(x|c_j)\right)^2 \cdot x \Big/ \sum_{x \in X_i} \left(\mu^S(x|c_j)\right)^2, \quad (6)$$

$$\sum_{x \in X_i} \left(\mu^S(x|c_j)\right)^2 \neq 0$$

where S is the iteration number; X_i is the set of learning objects that characterize the value function of the i-th characteristics of the IO to the elements of the set C.

The second step consists in the calculation of the values of the membership function of the i-th IO characteristics on the S-th iterations:

$$\mu^S(x|c_j) = \frac{1 \Big/ \left(x - V_{ij}\right)^2}{\sum_{j=1}^{|C|} \left(1 \Big/ \left(x - V_{ij}\right)^2\right)}, \quad \text{якщо} \ \left(x - V_{ij}\right)^2 > 0; \quad (7)$$

$$\mu^S(x|c_j) = 1, \quad \text{якщо} \ \left(x - V_{ij}\right)^2 = 0.$$

Both steps are performed iteratively until the difference of the obtained values of the class centers meets the condition

$$\left|V_{ij}^S - V_{ij}^{S-1}\right| \leq \varepsilon,$$

where ε is the minimum possible difference between the values of the centers of the classes that are obtained in two successive iterations.

The expression (7) allows to determine the function of belonging of the characteristics of the IO to the elements of the set C depending on its quantitative value.

The result of passing the vector of characteristics of the IO x through the first network layer is a synthesis of the second network layer whose function of vertices activation has the form

$$y_{2k} = \min\left(\mu(x|c_j)\right), i \in \overline{1,6}, j \in \overline{1,3}, \quad (8)$$

where $\mu(x_i)$ is the belonging function of the i-th characteristics that are used in the learning process of the object, the sample that trains up to the j-th element of the plural C.

The argument of expression (8) is determined by the values of the signals propagated by the vertex-parent vertices of the k fuzzy set graph C.

Step 4. Each neuron of the third and subsequent network layers receives a signal from all neurons of the previous layer, converting the received signal in accordance with the activation function and it is broadcasted to each neuron of the next layer.

Neuron function activation argument z_j is calculated according to the expression

$$z_j = w_{0j} + \sum_{i=1}^{n} y_i \cdot w_{ij}, \quad (9)$$

where n is the number of neurons in the previous layer.

Based on the value of the argument z_j, we calculate the value of the activation function of the neuron

$$y_j = f\left(z_j\right).$$

Step 5. The required continuation training of the artificial neural network is checked according to the defined criterion. If the stop criterion is fulfilled, the algorithm control flow is passed to step 9. The classifier error is calculated on the last layer of the artificial neural network according to the expression:

$$\varepsilon = \sum_{i=1}^{n} \left| d_i - y_i \right|,$$

Step 6. The error is backpropagated. Each neuron of the source layer receives a target value d_i that calculates the magnitude of the error σ_i:

$$\sigma_i = \left(d_i - y_i\right) \cdot f'\left(z_i\right),$$

where

$$f'\left(z_i\right) = f'\left(z_i\right) \cdot \left(1 - f\left(z_i\right)\right).$$

The correction value of the link axis Δw_{ji} is calculated, as well as the magnitude of the offset adjustment Δw_{0j}:

$$\Delta w_{ji} = \alpha \cdot \sigma_i \cdot z_j ; \Delta w_{0i} = \alpha \cdot \sigma_i .$$

The size of σ_i is sent to the neurons of the previous layer.

Step 7. Each inner layer neuron sums the input from the neurons in the next error layer σ_i and calculates the magnitude of the error by multiplying the value that is obtained by the derivative of the activating function.

$$\sigma_i = f'\left(z_i\right) \cdot \sum_{j=1}^{n} \sigma_j \cdot w_{ij} .$$

Computing the changes in the weights of connections between adjacent neurons according to the expression:

$$\Delta w_{ji} = \alpha \cdot \sigma_i \cdot z_j ; \Delta w_{0i} = \alpha \cdot \sigma_i .$$

Step 8. Each neuron changes the weight of its relation to the offset elements and the neurons of the previous layer:

$$w_{ji} = w_{ji} + \Delta w_{ji} .$$

Step 9. The final rank of the IO by the expression

$$r_i = \left| y_1 \; y_2 \; \ldots \; y_n \right| \times \left| c_1 \; c_2 \; \ldots \; c_n \right|^T ,$$

where c_i is the coefficients that characterize the quantitative measure of the corresponding characteristics of the set C.

An example of the implementation of the methodology

The automation of the IO ranking process is performed by using software that implements the developed method. A data snippet that defines the functions of the fuzzy network argument to the plural element C, that is shown in Table 1.

In Table 1, each characteristic of the IO is determined by four values $\mu_1, \mu_2, \mu_3, \mu_4$, where $.x.$ is the magnitude of the characteristic, μ_1 is the function of belonging to a value x to the i-th plural object C. A training sample of an artificial neural network is defined on a set of IOs that are characterized by a species vector

$$o = \left(x_1, x_2, x_3, x_4, x_5, x_6, c_1, c_2, c_3\right).$$

A fragment of the training sample artificial fuzzy neural network is shown in Table 2.

Table 1 – **Fragment of the value of the membership functions μ for arguments** $x_1, x_2, x_3, x_4, x_5, x_6$

x_1	μ_1	μ_2	μ_3	x_2	μ_1	μ_2	μ_3	x_3	μ_1	μ_2	μ_3
10	0,92	0,06	0,002	1,8	0	0,11	0,89	0	0	0,04	0,96
50	0,8	0,15	0,05	2,13	0,01	0,11	0,88	9	0,03	0,05	0,95
100	0,7	0,22	0,08	2,46	0,02	0,10	0,88	18	0,15	0,1	0,75
122,1	0,68	0,23	0,09	2,79	0,04	0,10	0,86	27	0,15	0,31	0,54

x_4	μ_1	μ_2	μ_3	x_5	μ_1	μ_2	μ_3	x_6	μ_1	μ_2	μ_3
700	0,01	0,1	0,89	0,9	0,01	0,09	0,9	7	0,01	0,1	0,89
600	0,02	0,13	0,85	0,8	0,1	0,25	0,65	7,4	0,02	0,13	0,85
500	0,03	0,17	0,80	0,7	0,15	0,33	0,52	7,8	0,03	0,17	0,8
450	0,04	0,22	0,74	0,6	0,21	0,54	0,25	8,2	0,04	0,22	0,74

Table 2 – **Fragment of a training sample of an artificial fuzzy neural network**

x_1	x_2	x_3	x_4	x_5	x_6	μ_1	μ_2	μ_3
600	1,8	0	200	0,85	7,0	0,01	0,10	0,89
600	1,8	0	200	0,85	7,0	0,01	0,24	0,75
600	3,0	0	200	0,85	7,0	0,01	0,24	0,75
600	1,8	0	200	0,65	7,0	0,1	0,3	0,6
600	1,8	0	200	0,85	11,0	0,01	0,2	0,79
600	1,8	0	200	0,85	7,0	0,01	0,35	0,64
300	1,8	0	200	0,85	7,0	0,01	0,1	0,89

Based on the analysis of the above data, we can conclude that the use of an artificial fuzzy neural network allows to realize the mapping

$$f\left(h_k\right) \to w_k$$

with a high degree of reliability of the obtained results. The mean square error of training of the neural network is 3.9 points of rank.

Thus, the results of the proposed method are reliable and can be used in solving the problem of scheduling the observation of the IO.

The conclusion from the article

Thus, the developed method takes into account the ranking of the IO that is performed in the framework of planning the use of intelligence, factors that affect the conditions of exposure of the IO and the operational situation. The use of a mathematical apparatus of fuzzy artificial neural networks allows to take into account the consequences of the use of reconnaissance tools for observing IO in the course of intelligence planning, to apply the principles of IO ranking depending on the dynamically changing operational environment.

The proposed method implements a comprehensive approach to solve the task of ranking the IO and provides the desired degree of effectiveness of the process of functioning of the intelligence system in different conditions of the operational environment.

The direction of further research is the development of practical recommendations for the integration of the developed method in intelligence and information support to increase the efficiency of planning the collection and processing of intelligence information on the IO.

References

1. Shyshatskiy, A.V., Bashkirov, O.M. and Kostina, O.M. (2015), "Development of integrated systems and data for Armed Forces", *Arms and military equipment*, No 1(5), pp. 35-40.
2. Hatsenko, S.S. (2017), "Methodology for assessing the operational situation in automated control systems of troops under uncertainty", *Science and Technology of the Air Forces of the Armed Forces of Ukraine*, No. 1 (26), pp. 101-105, DOI: https://doi.org/10.30748/nitps.2017.26.21.
3. Kalantaievska, S., Pievtsov, H., Kuvshynov, O., Shyshatskyi, A., Yarosh, S., Gatsenko, S., Zubrytskyi, H., Zhyvotovskyi, R., Petruk, S. and Zuiko, V. (2018), "Method of integral estimation of channel state in the multiantenna radio communication systems.", *Eastern-European Journal of Enterprise Technologies*, Vol 5, No 9 (95), pp 60-76, DOI: https://doi.org/10.15587/1729-4061.2018.144085.
4. Babul, V.A. and Sverbut, A.M. (2014), *Control systems and radio engineering foreign armed forces*, Minsk, 263 p
5. Kalantaievska, S., Malyk, O., Tiurnikov, M., Zhuk, P., Shyshatskiy, A. and Pikul, R. (2019), "Foundation the ways of radio electronic warfare devices development", *Advanced information systems*, Vol. 3, No. 2, pp. 80-85, DOI: https://doi.org/10.20998/2522-9052.2019.2.14
6. Yakhno, I., Malyk, O., Hatsenko, S., Shyshatskiy, A. and Pikul, O. (2019). "Method of assessment of information availability of radio inflammation sources by devices of radioelectronic recognition, *Advanced information systems*, 2019, No. 3(1), pp. 98-103, DOI: https://doi.org/10.20998/2522-9052.2019.1.16
7. Shyshatskiy, A., Hordiichuk, V., Sergienko, V., Mishchenko, A. and Pozdniakov, P. (2019), "Analysis of technical characteristics of the radioelectronic intelligence of the Russian Federation", *Control, navigation and communication systems*, No. 1 (53), pp. 142-146, DOI: https://doi.org/10.26906/SUNZ.2019.1.142
8. Shyshatskiy, A., Yakhno I., Malyk, O. and Hatsenko, S. (2019), "Foundation of the factors affecting the planning and management of the radioelectronic developmen". *Control, navigation and communication systems*, No.1 (53), pp. 162-167, DOI: https://doi.org/10.26906/SUNZ.2019.1.162

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Метод ранжування об’єктів розвідки під час обробки розвідувальних відомостей

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Анотація. Результативність процесу функціонування сил і засобів розвідки визначається кількістю викритих об’єктів розвідки і якістю добутої про них розвідувальної інформації. В свою чергу вказані показники залежать від ступеня відповідності результатів вирішення завдання планування застосування сил і засобів розвідки, у відповідності до умов оперативної обстановки. Разом з тим, коли кількість множини ранжуємих об’єктів розвідки має велику кількість, існуючий підхід ранжування об’єктів розвідки не дозволяє реалізувати адаптивне раціональне планування застосування засобів розвідки. В статті пропонується вирішення актуального наукового завдання розробки науково-методичного апарату ранжування об’єктів розвідки при оцінці оперативної обстановки, в інтересах планування розвідки. Ранг об’єкту розвідки розраховується з урахуванням його якісних і кількісних характеристик. Функціональні залежності рангу об’єкта розвідки від його розвідувальної цінності і ототожнення його з оперативною обстановкою реалізується нечіткою штучною нейронною мережею. В ході проведеного дослідження авторами використані методи штучного інтелекту, теорії обробки інформації, метод аналізу ієрархій та загальнонаукові методи аналізу та синтезу. Результатом виконання процедури ранжування є введення на множині об’єктів розвідки, що плануються, відношення порядку. Впорядкування множини об’єктів розвідки дозволяє формалізувати і вирішити завдання квазіоптимального розподілу засобів і сил розвідки. Практична значимість проведеного авторами дослідження полягає в тому, що запропонований метод доцільно використовувати при розробці програмного забезпечення для систем підтримки прийняття рішень, які призначені для вирішення завдань розвідувального забезпечення дій військових формувань сектору національної безпеки та оборони.

Ключові слова: ранжування; об’єкти розвідки; планування розвідки; нечіткі множини; штучні нейронні мережі; застосування сил і засобів розвідки.

Метод ранжирования объектов разведки во время обработки разведывательных сведений

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Аннотация. Результативность процесса функционирования сил и средств разведки определяется количеством раскрытых объектов разведки и качеством добытой о них разведывательной информации. В свою очередь указанные показатели зависят от степени соответствия результатов решения задачи планирования применения сил и средств разведки, в соответствии с условиями оперативной обстановки. Вместе с тем, когда количество множеств ранжируемых объектов разведки имеет большое количество, существующий подход ранжирование объектов разведки не позволяет реализовать адаптивное рациональное планирование применения средств разведки. В статье предлагается решение актуальной научной задачи разработки научно-методического аппарата ранжирование объектов разведки при оценке оперативной обстановки, в интересах планирования разведки. Ранг объекта разведки рассчитывается с учетом его качественных и количественных характеристик. Функциональные зависимости ранга объекта разведки от его разведывательной ценности и отождествление его с оперативной обстановкой реализуется нечеткой искусственной нейронной сетью. В ходе проведенного исследования авторами использованы методы искусственного интеллекта, теории обработки информации, метод анализа иерархий и общенаучные методы анализа и синтеза. Результатом выполнения процедуры ранжирования является введение на множестве объектов разведки, планируемых отношение порядке. Упорядочение множества объектов разведки позволяет формализовать и решить задачу квазиоптимального распределения средств и сил разведки. Практическая значимость проведенного авторами исследования заключается в том, что предложенный метод целесообразно использовать при разработке программного обеспечения для систем поддержки принятия решений, которые предназначены для решения задач разведывательного обеспечения действий военных формирований сектора национальной безопасности и обороны.

Ключевые слова: ранжирование; объекты разведки; планирования разведки; нечеткие множества; искусственные нейронные сети; применение сил и средств разведки.