The problem that is solved in the research is to increase the efficiency of decision making in management tasks while ensuring the given reliability, regardless of the hierarchy of the system. The object of the research is the decision making support system in the field of democratic civilian control over the security and defense sector (FDCCSDS). The subject of research is the decision making process in management tasks using fuzzy cognitive maps and evolving artificial neural networks. The hypothesis of the research is to increase the number of sources of information about the components of the FDCCSDS, with restrictions on the efficiency and reliability of decision making. The research proposed a method for evaluating the information and analytical provision of public administration in FDCCSDS. It was established that the proposed method has a higher efficiency compared to the known ones by an average of 40 %, compared to the methods used to evaluate the effectiveness of strategic management decisions. The specified method will make it possible to assess the state of information and analytical provision of public administration in the FDCCSDS and to determine effective measures to improve efficiency. The method will allow to analyze possible options for the development of FDCCSDS in each phase of development and moments in time when it is necessary to carry out structural changes that ensure the transition to the next phase. At the same time, subjective factors of choice are taken into account while searching for solutions, which are formalized in the form of weighting coefficients for the components of the integral criterion of efficiency. The specified method allows to increase the speed of assessment of the state of information and analytical support of the FDCCSDS, to reduce the use of computing resources of and decision making support systems, to form measures aimed at increasing the efficiency of information and analytical support

Keywords: vague cognitive models, civilian control over the security and defense sector of Ukraine

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DEVELOPMENT OF INFORMATION AND ANALYTICAL PROCUREMENT METHODOLOGY OF PUBLIC ADMINISTRATION IN THE SPHERE OF PROVIDING CIVIL CONTROL OVER THE SECTOR OF SECURITY AND DEFENSE OF UKRAINE

Olha Salnikova
Corresponding author
Doctor of Science in Public Administration,
Senior Researcher, Deputy Chief
General Directorate of Military Cooperation Ukrainian Armed Forces
Dehtiarivska str., 28, Kyiv, Ukraine, 04119
E-mail: o.f.salnikova@post.mil.gov.ua
Rena Marutian
Doctor of Science in Public Administration, Associate Professor
Department of Global and National Security
Educational and Scientific Institute
of Public Administration and Civil Service
Taras Shevchenko National University of Kyiv
Volodymyrska str., 60, Kyiv, Ukraine, 01033
Oleksandr Vereschak
Postgraduate Student
O. M. Beketov National University of Urban Economy in Kharkiv
Marshala Bazhanova str., 17, Kharkiv, Ukraine, 61002

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1. Introduction

Democratic civilian control in the context of military-civilian relations is one of the interdisciplinary fields of social science, because historians, cultural scientists, political scientists and legal scholars have made a great contribution to the research of this phenomenon. Important components of ensuring the effectiveness of democratic civil control should be specified as [1, 2]:

– the unification of efficiency research methodology;
– the argumentation for making balanced decisions;
– the implementation control.

It is necessary to have clarity and consistency of interaction of all resources:

– financial, personnel, material and technical, administrative and organizational, legal;
– a clear agreed list of criteria for evaluating aims and results, substantiation of proposals, procedures for selecting alternatives;
– a delimitation (delegation) of the functions of distribution of powers and responsibilities of management and control subjects.

Democratic civil control is carried out in two varieties: public and authoritative, which is determined by the specifics of public administration in any democratic state.

The list of these measures represents a legal framework for the exercise of public administration of democratic civilian control, but in reality the mechanisms that affect the ability

of the military to carry out any subversive actions. An implementation of public management in the sphere of ensuring civilian control over the security and defense sector in Ukraine takes place through a number of relevant control processes:

– of civil justice – over the seriousness of military decisions;

– parliamentary – due to the objectivity of the state's defense policy;

– judicial – due to the observance of legality in the military sphere;

– civilian – from the side of non-governmental organizations, independent mass media, trade unions, etc.

Full and objective consideration of all factors (resources) that affect the effectiveness of the functioning the public administration system in the sphere of ensuring civilian control over the security and defense sector of Ukraine requires a reduction in subjectivism. This, in turn, requires a minimal role of decision-makers. The above requires processing various types of data on the state of the public administration system in the field of ensuring civilian control over the security and defense sector of Ukraine, which are different in origin and measurement units [1–5].

Therefore, the issue of introducing new information technologies that would allow to fully and objectively assess the effectiveness of the public administration system in the sphere of civil control over the security and defense sector of Ukraine is becoming urgent. Decision making methods, the improvement of which is carried out on the basis of complex automation and informatization [6, 7], have a great impact on the effectiveness of this complex task.

The specificity of this field of research also lies in the fact that it includes both open information with limited access. Currently, there are no publicly available information systems capable of fully implementing objective and full democratic civilian control over the security and defense sector of Ukraine.

The creation and implementation of new highly effective automated systems and decision making support information technologies into the work practice of managers is an important direction for improving the effectiveness of civilian control over the security and defense sector of Ukraine.

In such conditions, the development of methods for multi-criteria evaluation of the efficiency of system functioning becomes important civil control over the security and defense sector of Ukraine for their subsequent introduction into automated and information systems.

In the course of the research, a method for evaluating the information and analytical provision of public administration in the sphere of civil control over the security and defense sector of Ukraine was proposed.

2. Analysis of literary data and formulation of the problem

The work [8] describes an agent-based approach that is used in a multi-agent information and analytical system and considers the problems of information support for decision making. The limitations of the representation of complex systems should be attributed to the shortcomings of the mentioned approach, namely, none of the agents has an idea of the entire system.

The work [9] provides an operational approach for spatial analysis in the marine industry for the quantitative assessment and display of accompanying ecosystem services. This approach covers the three-dimensionality of the marine environment by considering all marine regions (sea surface, water column and seabed) separately. In fact, the method builds 3-dimensional models of the sea by estimating and mapping those associated with each of the three marine domains through the adoption of representative indicators. The disadvantages of the specified method include the impossibility of flexible setting (adaptation) of assessment models while adding (removing) indicators and changing their parameters (compatibility and significance of indicators).

The work [10] presents a machine-learning model for automatic identification of requests and provision of information support services exchanged between members of the Internet community. This model is designed to process a large number of messages from users of social networks. The disadvantages of the specified model are the lack of mechanisms for assessing the adequacy of the decisions made and the high computational complexity.

The work [11] presents a method of analyzing large data sets. The specified method is focused on finding hidden information in large data sets. The method includes the operations of generating analytical baselines, reducing variables, detecting sparse features and specifying rules. The disadvantages of this method include the impossibility of taking into account different decision evaluation strategies.

The work [12] proposed an approach for estimating the cost of living of a client in the field of air transportation. In this approach, a regression model is used firstly and an indirect estimation model is used then. At the final stage, the evaluation results are compared using both evaluation models. The disadvantages of the mentioned approach include the impossibility of determining the adequacy of the obtained assessment.

The work [13] presents an approach to quantitative assessment that is intended for evaluating the optimal selection and/or testing of analytical methods. Objective criteria related to analytical performance, sustainability, environmental impact and economic costs are evaluated by defining penalty points divided into five different blocks. For each block, the overall qualification is scaled from 0 to 4 and is represented by a regular hexagonal icon, allowing comparison of analytical procedures. The disadvantages of this approach include the lack of an opportunity to increase the number of evaluated indicators.

The work [14] presents the mechanism of transformation of information models of construction objects to their equivalent structural models. This mechanism is intended to automate the necessary conversion, modification and addition operations during such information exchange. The disadvantages of the mentioned approach include the impossibility of assessing the adequacy and reliability of the information transformation process. Also, the disadvantage of the mentioned approach is the lack of consideration of uncertainty about information about the object state.

The work [15] developed an analytical web platform for the research of the geographical and temporal distribution of incidents. Web-platform, contains several information panels with statistically significant results by territory. The web-platform includes certain external sources of data on social and economic issues that allow to research the relationship between these factors and the distribution of incidents at different geographic levels. The disadvantages of the specified analytical platform include the impossibility of assessing the adequacy and reliability of the information transformation process and high computational complexity.

The work [16] developed a method of fuzzy hierarchical assessment of library service quality. The specified method allows to evaluate the quality of libraries based on a set of input parameters. Among the disadvantages of the specified method should be attributed the impossibility of assessing the adequacy and reliability of the assessment.

The analysis of works [1–16] showed that the vast majority are based on the use of general scientific methods, such as systematic, comparative, structural and functional analysis, the method of expert evaluations, the methodology of scenario analysis of socio-economic systems and the theoretical and informational approach.

Common limitations of existing methods of multi-criteria evaluation of alternatives are [17–28]:

– the complexity of forming a multi-level evaluation structure;

– the lack of consideration of the compatibility of unevenly significant indicators;

– the lack of consideration of uncertainty about the state of the system of democratic civilian control over the security and defense sector;

– the lack of possibility of joint performance of direct and reverse assessment tasks with the support of choosing the best solutions.

To create software tools to decision making support systems of information and analytical of democratic civilian control over the security and defense sector, it is necessary to create evaluation methods that must satisfy the following set of requirements [29–31]:

– the possibility of forming a generalized evaluation indicator and choosing solutions based on sets of partial indicators that change taking into account the complex multi-level evaluation structure;

– the possibility of aggregating disparate indicators (both quantitative and qualitative) of assessment and selection of solutions that differ in measurement scales and ranges of values;

– taking into account the compatibility and different importance of partial indicators in the generalized assessment of decisions;

– the consideration of various decision evaluation strategies;

– flexible setting (adaptation) of evaluation models while adding (removing) indicators and changing their parameters (compatibility and significance of indicators);

– ensuring the possibility of implementation within the framework of a single model: the direct task of evaluating a generalized indicator based on partial indicators; inverse assessment task and joint performance of direct and inverse assessment tasks.

For this purpose, it is proposed to develop a method that would allow to evaluate complex information and analytical support in decision making support systems of civil control over the security and defense sector of Ukraine. The specified method should have a flexible setting, implement direct and reverse evaluation within the framework of a single model.

3.The aim and objectives of the research

The aim of research is to develop a method for evaluating information and analytical support in decision making support systems of civil control over the security and defense sector of Ukraine using fuzzy logic.

To achieve the aim, the following tasks were set:

– to develop an algorithm for the evaluation method of information and analytical support in decision making support systems of civil control over the security and defense sector of Ukraine;

– to propose information system architectures.

4. Research materials and methods

In the course of the research, the general provisions of the theory of artificial intelligence were used to solve the problem of analyzing the state of the system of democratic civilian control over the security and defense sector. Thus, the theory of artificial intelligence is the basis of the mentioned research. The research uses fuzzy cognitive models and evolving artificial neural networks. The simulation was carried out using MathCad 2014 software (USA) and an Intel Core i3 PC (USA).

The problem that is solved in the research is to increase the efficiency of decision making in management tasks while ensuring the given reliability, regardless of the hierarchy of the system. The object of the research is decision making support system of democratic civil control over the security and defense sector. The subject of research is the decision making process in management tasks using fuzzy cognitive maps and evolving artificial neural networks. The research hypothesis is to increase the number of sources of information about the components of the system of democratic civilian control over the security and defense sector of Ukraine with restrictions on the efficiency and reliability of decision making. Possible solutions to this problem are:

– the use of high-performance computing methods (in our case, the theory of artificial intelligence) with the aim of forming a system of interrelationships between the components of the system of democratic civil control and working with various types of data;

– in the case of impossibility of solving the problem with available computing resources and using the theory of artificial intelligence to make a decision to involve additional computing resources.

5. Development of a method for evaluating information and analytical support in decision making support systems

5. 1. Development of an algorithm for evaluating information and analytical support

The algorithm for evaluating information and analytical support in decision making support systems of civil control over the security and defense sector of Ukraine consists of the following sequence of actions (Fig. 1):

1. Input of initial data. At this stage, initial data on the state of the system of democratic civilian control over the security and defense sector are introduced. The number of sources of information about the state of the system of democratic civilian control over the security and defense sector of Ukraine, the type of initial data and their volume is determined. The available financial, personnel, material and technical, administrative and organizational and legal resources are introduced.

2. Determination of the degree of uncertainty of the initial data. At this stage, the degree of uncertainty of the initial data is determined based on the authors' previous research. Uncer-

tainty in this research refers to the degree of completeness of information that covers the components of the system of democratic control of the security and defense sector. The degree of uncertainty of the initial data is the following: complete uncertainty; partial uncertainty and complete awareness [29–31].

3. Reducing the dimensionality of the space of signs of the system state of democratic civilian control over the security and defense sector.

Reducing the feature space is a necessary task in any information systems. First of all, it is aimed at reducing the number of computing resources of the system, which are used to solve problems of assessment and decision making.

The task of reducing the dimensionality of the space of signs about the state of the system of democratic civilian control over the security and defense sector has the following form:

$$X_1 \times ... \times X_m \to Y_1 \times ... \times Y_n, n < m, \quad (1)$$

where $X_1,...X_m$ is the initial set of features of the state of the system of democratic civilian control over the security and defense sector, $Y_1,...Y_n$ is the new set of features of the state of the system of democratic civilian control over the security and defense sector, m is the dimension of the initial space of features of the state of the system of democratic civil control over the security and defense sector, n is the dimension of the new space of signs of the state of the system of democratic civilian control over the security and defense sector. Each of the signs has its own scale $X_i = \left\{x_i^1,...,x_i^{g_i}\right\}$, $i = 1,...,m$, $Y_i = \left\{y_i^1,...,y_i^{h_i}\right\}$, $j = 1,...,n$, with an orderly gradation of grades.

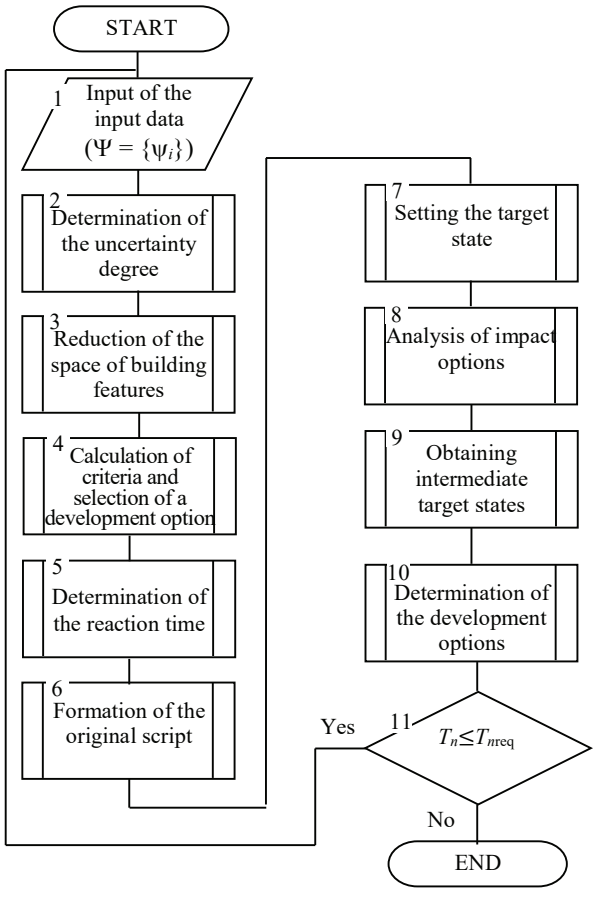

Fig. 1. Algorithm for the implementation of a complex method for evaluating the information and analytical support of civil control over the security and defense sector of Ukraine

All gradations of evaluations on the scales of signs act are taken as objects of classification. Grades of assessments on the scale of the composite criterion act as classes of solutions of the i-th level. In the classification block of the (i+1)-th level of the hierarchy, the component criteria of the i-th level are considered features, the set of evaluation gradations of which are new objects of classification in the reduced space of features and the decision classes will now be the evaluation gradations on the scale of the composite criterion (i+1)-th level. The procedure is repeated until there remains a single upper-level composite criterion, the rating scale of which forms the necessary ordered decision classes C_1, ..., C_q.

In this way, a mutual and unambiguous correspondence is established between the classes of decisions about the state of the system of democratic civilian control over the security and defense sector C_1, ..., C_q and the set of initial indicators – the set X_1,... X_m of all possible combinations of rating gradations on the criteria scales $X_i = \left\{x_i^1,...,x_i^{g_i}\right\}$, i=1,...,m criteria K_1, ..., K_m and the boundaries of the classes are located, which makes it easy to build a classification of real alternatives A_1, ..., A_p, evaluated by many criteria.

4. Calculation of criteria and determination of development options.

The method, which is being developed, is designed to solve the tasks of both direct and reverse planning of the state of development of the system of democratic civilian control over the security and defense sector.

The value of the input parameters $\{X_i\}$ and the structure of the system-dynamic model of the state of the system of democratic civil control over the security and defense sector determine the dynamics of the A_i value over time (i is the number of the computational experiment).

5. Determination of the response time of informational democratic civil control over the security and defense sector.

To calculate the criteria, it is necessary to take into account the initial speed of development of events occurring in the system of democratic civilian control over the security and defense sector – A_0, the maximum achievable speed of development of the event $A_{\max}$ and the time to reach $A_{\max}$, which is equal to $t_{\max}$. During simulation modeling, options for the development of the state of the system of democratic civilian control over the security and defense sector, under which the value of the speed of the development of the event falls below the value of $A_0/2$, are not considered, since this trend reflects negative processes.

To take into account the end of the development phase of the state of the system of democratic civil control over the security and defense sector, the time characteristic t_{stop} is considered, which contains information about the time of stopping the computational experiment. Its value can be determined by calculating $A_{\text{stop}}=kA_{\max}$, where k is a parameter, and $0<k<1$. Since there are usually two such values at which $A=A_{\text{stop}}$, the time characteristic at which $t_{\text{stop}}>t_{\max}$ is considered.

6. Formation of the initial scenario of the state of the system of democratic civilian control over the security and defense sector.

As a result of a series of N computational experiments, connected sets of input and output data on the state of the system of democratic civilian control over the security and defense sector are formed: $\overline{X}_i \to \overline{Y}_i, i = \overline{1,N}$.

For each vector data set $\overline{Y}_i$ normalization of the values of the elements $A_{\max}$, $t_{\max}$, S_p is carried out:

$$A^{norm}_{\max_i} = A_{\max_i} \Big/ \max\left(A_{\max_i}\right)\Big|_{i=1,...N},$$

$$S^{norm}_{p_i} = S_{p_i} \Big/ \max\left(S_{p_i}\right)\Big|_{i=1,...N}, \quad (2)$$

$$t^{norm}_{\max_i} = t_{\max_i} \Big/ \max\left(t_{\max_i}\right)\Big|_{i=1,...N},$$

where $N=|\{x_1\}*\{x_2\}*\{x_3\}|$ is the number of variants of computational experiments regarding the state of the system of democratic civilian control over the security and defense sector.

7. Establishing the target state of the system of democratic civilian control over the security and defense sector.

Using the obtained values of the necessary parameters, the K_{ri} criteria are calculated for each scenario, taking into account the weights of the indicators ($0<wes_*<1$) set on the basis of user preference, which characterize the effective management of the development of the system of democratic civilian control over the security and defense sector:

$$K_{r_i} = wes_1 \cdot Sp^{norm}_i + wes_2 \cdot A^{norm}_{\max_i} - wes_3 \cdot t^{norm}_{\max_i}, i = \overline{1,N}. \quad (3)$$

8. Analysis of options for influencing the state of the system of democratic civilian control over the security and defense sector.

Parameters and results $\overline{X}_{req} = \overline{X}_j$; $\overline{Y}_{req} = \overline{Y}_j$, which must be found, of the j-th computational experiment, for which the obtained value of the criterion is maximal:

$$K_{r_j} = K_{r_{\max}} = \max\left(K_{r_i}\right)\Big|_{i=1,...,N}.$$

9. Obtaining intermediate target states of the system of democratic civil control over the security and defense sector.

The search on the time axis of the point t_{req} of the effective transition to the next phase of the development of the system of democratic civilian control over the security and defense sector is carried out by conducting another series of simulations taking into account the change at each point $[t^-, t^+]$, determined with some step Δt. As a result of the calculation of the criteria for the newly obtained options, the desired t_{req} point is determined.

If necessary, a new set of values can be specified at the t_{req} point $\overline{X}'$. The point of transition to the next phase t'_{req} is determined according to a similar scheme, but with a change in the structure and possibly parameters of the state model of the system of democratic civilian control over the security and defense sector at the t_{req} point.

Then a set of values $\left(X_{req}, X'_{req}, X''_{req}, t_{req}, t'_{req}, A''_{stop}\right)$ is formed, which includes:

– X_{req}, X'_{req}, X''_{req} are the sets of parameters characterizing the state of the system of democratic civilian control over the security and defense sector at the beginning of each of the analyzed phases of development;

– t_{req}, t'_{req} are the points corresponding to the moments of time of the implementation of structural changes, which translate each of the phases of the development of the system of democratic civilian control over the security and defense sectors, respectively;

– A''_{stop} is the value of the speed of development at the end of the time interval of forecasting the state of the system of democratic civilian control over the security and defense sector.

This set determines the best option for the development of the object of analysis under the given initial conditions X_{req}.

10. Determination of options for the development of the system of democratic civilian control over the security and defense sector.

The system of states for determining options for the development of the state of the system of democratic civilian control over the security and defense sector is the final weighted oriented graph *Gr*. The vertices of the graph mutually uniquely correspond to the states of the system, characterized by the current speed of the event (A_b), the arcs – control, determined by a set of parameters ($\overline{X}_b$), the weight of arcs w_b is the cost of the corresponding transitions, which are calculated according to the following formula:

$$w_b = \sum A_b - fond_b, fond_b \geq 0, b = \overline{1,l}, \quad (4)$$

where $\sum A_b$ is the total value of the cost of the system of democratic civilian control over the security and defense sector in the b-th simulation experiment; $fond_b$ are the corresponding additions included in the analysis object, l is the number of scenarios that leads to the specified states.

To determine the necessary trajectory of the system development, which ensures the achievement of the target state, the best path is calculated on the formed graph *Gr* by the method of dynamic programming in accordance with the Bellman optimality principle.

According to the theory of the dynamic programming method [17], the system *Sys* is considered, which is translated from the initial state Sys_0 to the final state Sys_{end} as a result of some *Manag* control, which is divided into a finite number of *Step* steps. It is taken into account that decision making is carried out consistently at each step. The control that switches the system *Sys* under consideration from the initial state Sys_0 to the final Sys_{end} will be a set of step-by-step controls *Step*, each of which is characterized by the corresponding value of the function *W*(*Manag*).

The solution to the problem of dynamic programming of the system of democratic civilian control over the security and defense sector consists in finding from all possible management *Manag* such $Manag^*$, in which the function *W*(*Manag*) will acquire the maximum (minimum) value of $W(Manag^*)$.

It is assumed that the state of the system of democratic civilian control over the security and defense sector S_{ys} under consideration is determined at each z-th step by a numerical set $XS^{(z)} = \left(xs_1^{(z)}, xs_2^{(z)}, ..., xs_n^{(z)}\right)$. This sequence is formed due to the implementation of $Manag_z$ governing influences, which ensure the transition of the system of democratic civilian control over the security and defense sector from the previous state $XS^{(z-1)}$ to the next one – $XS^{(z)}$. Moreover, the state of $XS^{(z)}$ depends only on the state of $XS^{(z-1)}$ and the chosen method of $Manag_z$ management, but not on the method of transition to a new state of the system of democratic civilian control over the security and defense sector.

If the implementation of the z-th step leads to the receipt of a certain income $W_z(XS^{(z-1)}, manag_z)$, which also depends on $XS^{(z-1)}$, then the entire income while passing all steps will be:

$$Gain = \sum_{z=1}^{Step} W_z\left(X^{(z-1)}, Manag_z\right). \quad (5)$$

Solving the problem of dynamic programming implies finding such a set of ways of managing the system of democratic civilian control over the security and defense sector $Manag^* = \left(manag_1^*, manag_2^*, ..., manag_{step}^*\right)$, the application of

which brings the system from the initial state to the final state and the total gain depending on the management aim (5) acquires the greatest value.

11. Verification of the significance of the efficiency of the adopted decisions on the state of the system of democratic civilian control over the security and defense sector.

At this stage, the permissible decision making time in the task of assessing and forecasting the state of the system of democratic civilian control over the security and defense sector is determined.

Criterion of efficiency of the decisions made T_n with the reliability of D not less than the permissible D_{add} ($D \geq D_{\text{add}}$).

Finding the optimal strategy is possible by sequentially determining the optimal control strategies at the last step, then the last two steps are considered, then three, and so on, until we reach the initial state of the system. At the same time, it is necessary to take into account conditionally optimal management of all possible results of the previous step.

When the initial state is reached, similar operations are performed, but in the reverse direction – from the initial state to the final state.

In order to assess the effectiveness of the developed method for evaluating information and analytical support in decision making support systems of the system of democratic civilian control over the security and defense sector, it was compared with the most popular software products that can be used for similar purposes:

– ARIS Business Performance Edition (IDS Scheer AG, Germany);

– IBM WebSphere Business Modeler (IBM, USA);

– System21 Aurora (Campbell Lee Computer Services Limited, Great Britain);

– SAP Strategic Enterprise Management (SAP, Germany);

– Hyperion Performance Scorecard (Oracle, USA),

– CA ERWin Process Modeler (CA, USA).

5. 2. Information system architecture using the proposed method

The input data for evaluating the effectiveness of the application of the proposed method in the information and analytical system for the needs of democratic control over the security and defense sector are the following:

– legislative power (the Verkhovna Rada of Ukraine). The total number of legislative acts in the database is 36 in our case;

– executive power (President of Ukraine, Cabinet of Ministers of Ukraine, Defense Ministry of Ukraine). The total number of legislative acts in the database is 573 in our case;

– internal civilian democratic control of the Armed Forces of Ukraine and other components of the security and defense sector. The total number of legislative acts in the database is 2382 in our case;

– judiciary. The total number of court cases in the database is 547 in our case;

– mass media and civil society. The total number of high-profile cases in the database is 24 in our case.

The information and analytical system for the needs of democratic control over the security and defense sector using the developed method is shown in Fig. 2.

It is based on the database management system (DBMS) MySQL, server subsystem and client subsystem.

Physically, this complex of programs can be placed on a server under the control of any server operating system, for example, Windows 2016 Server, Ubuntu 18.04 Server, etc.

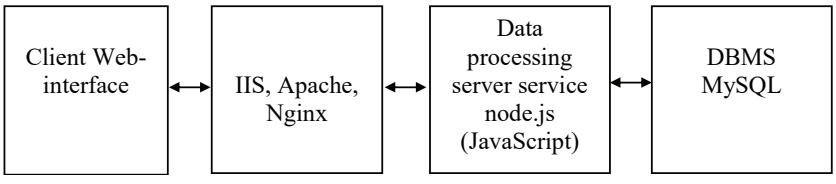

Fig. 2. Functional scheme of the complex of programs of the information and analytical system

The basis of the data storage and accumulation system in the "Data lake" in physical form is the MySQL DBMS. The table structure of the MySQL database of civil control over the security and defense sector of Ukraine consists of the following tables:

– table "table1" contains information obtained from open sources of information. In addition, the table has fields for identification of the operator who entered data into the "Data lake" and possible conclusions formed by the data user;

– table "source1" contains information on the amount and type of information on resources that are used in the interests of the security and defense sector. This information is classified as confidential. Therefore, the specified system must have access to protected information systems in which information classified as "secret" and higher circulates;

– table "pidrozd" contains fields that allows to reveal the affiliation of one or another subdivision to a group and to indicate its geographic coordinates, if available. This information is classified as confidential. Therefore, the specified system must have access to protected information systems in which information classified as "secret" and higher circulates;

– table "order" contains fields that allow to analyze the orders of the top management of the Armed Forces of Ukraine and other components of the security and defense sector. This information is classified as confidential. Therefore, the specified system must have access to protected information systems in which information classified as "secret" and higher circulates;

– table "radmer" table contains disparate data about the information component around the security and defense sector;

– the "user" and "owner" tables are created to separate users and grant them access rights to the system and monitoring of a specified group of messages.

Table 1 shows a comparative analysis of the developed method from the known ones according to the criterion of computational complexity.

The results of the comparison, carried out according to the criterion of calculation time equal to the number of calculations of the object, are given in the Table 2.

Analysis of the Tables 1, 2 testifies to the following:

– the proposed method has a larger number of calculations than the known ones, on average 10–14 %. This is due to a larger number of input data, which characterize the state of the system of democratic civilian control over the security and defense sector by an average of 40 %;

– while evaluating the state of the system of democratic civilian control over the security and defense sector by the evaluation time criterion, while evaluating the same evaluation objects and the same amount of input data, the efficiency is on average 50–54 % higher than the above.

Table 1

Comparison of the computational complexity of the software and the developed method for assessing the state of the system of democratic civilian control over the security and defense sector

No. n/p	The name of the software	The number of calculations	The developed method (by the number of calculations)
1	ARIS Business Performance Edition (IDS Scheer AG)	67000	69300
2	IBM WebSphere Business Modeler (IBM)	64500	66724
3	System21 Aurora (Campbell Lee Computer Services Limited)	57000	58388
4	SAP Strategic Enterprise Management (SAP)	39830	42586
5	Hyperion Performance Scorecard (Oracle)	46200	49580
6	CA ERWin Process Modeler (CA)	43050	45236

Table 2

Comparison of computing time of the software and the developed method for assessing the state of the system of democratic civilian control over the security and defense sector

No. n/p	The name of the software	Time, ms	Developed method (time, ms)
1	ARIS Business Performance Edition (IDS Scheer AG)	0.49	0.37
2	IBM WebSphere Business Modeler (IBM)	0.46	0.36
3	System21 Aurora (Campbell Lee Computer Services Limited)	0.37	0.27
4	SAP Strategic Enterprise Management (SAP)	0.28	0.19
5	Hyperion Performance Scorecard (Oracle)	0.33	0.24
6	CA ERWin Process Modeler (CA)	0.31	0.23

6. Discussion of the results of the development of the method for evaluating information and analytical support

A method for evaluating information and analytical support in decision making support systems for democratic control over the security and defense sector is proposed. Simulation of the work of the proposed method was carried out in the MathSad 14 software environment.

In the course of the research, an algorithm was developed for the evaluation of information and analytical support for democratic control over the security and defense sector using fuzzy logic and artificial neural networks.

As can be seen from the Tables 1, 2, the advantage of the mentioned method in comparison with the known ones is the reduce of the evaluation time, which in turn increases the efficiency of decision making regarding the system of democratic control over the security and defense sector.

The main advantages of the proposed evaluation method are:

– it has a flexible hierarchical structure of indicators, which allows reducing the task of multi-criteria evaluation of alternatives to one criterion or using a vector of indicators for selection;

– it allows to reduce the space of features that are the subject to priority assessment in the system of democratic control over the security and defense sector;

– the unambiguity of the received assessment of the state of information and analytical support of the system of democratic control over the security and defense sector;

– wide scope of use (decision making support systems);

– simplicity of mathematical calculations;

– no accumulation of errors during training;

– taking into account the type of uncertainty about the state of the system of democratic control over the security and defense sector;

– the possibility of adapting the system of indicators during work;

– the possibility of synthesizing the optimal structure of the decision making support system.

It is advisable to use the developed method in automated management systems and decision making support systems regarding the system of democratic control over the security and defense sector in order to increase the efficiency and reliability of the decisions made.

The limitations of the research should be considered the availability of sufficient computing resources and the availability of prior information about the system of democratic control over the security and defense sector. Also, one of the limitations should be considered the availability of information about the degree of uncertainty of information about the system and the availability of a comprehensive system of information protection in terms of the protection of information that is a state secret.

The disadvantages of the proposed method include:

– lower accuracy of assessment on a single parameter of assessment of the state of information and analytical support of the system of democratic control over the security and defense sector;

– the need for a decision maker to indicate the type of uncertainty regarding the state of the system of democratic control over the security and defense sector;

– lower assessment accuracy compared to other assessment methods.

This method will allow:

– to carry out an assessment of the state of information and analytical provision of the system of democratic control over the security and defense sector;

– to determine effective measures to increase the efficiency of information and analytical provision of the system of democratic control over the security and defense sector;

– to analyze possible options for the development of the system of democratic control over the security and defense sector in each phase of development and moments in time when it is necessary to carry out structural changes that ensure the transition to the next phase. At the same time, subjective factors of choice (advantages of the decision maker) are taken into account while searching for solutions, which are formalized in the form of weighting coefficients for the components of the integral efficiency criterion. The maximization of the criteria, calculated taking into account the advantages, makes it possible to determine the best option for the development of the system of democratic control over the security and defense sector;

– to increase the speed of assessment of the state of information and analytical provision of the system of democratic control over the security and defense sector;

– to reduce the use of computing resources of the decision making support systems of the system of democratic control over the security and defense sector;

– to develop measures aimed at increasing the efficiency of information and analytical support.

According to the results of the analysis of the efficiency of the proposed method, it can be seen that its efficiency is on average 40 % higher, compared to the methods used to evaluate the efficiency of the adopted decisions, which are presented in the Table 2.

This research is a further development of the research carried out by the authors, which is aimed at the development of methodological principles for increasing the efficiency of information and analytical support [26, 29, 30].

The directions of further research should be aimed at reducing computing costs when processing various types of data in systems of democratic control over the security and defense sector.

7. The conclusions

1. The research developed an algorithm for information and analytical provision of public administration in the field of civil control over the security and defense sector of Ukraine. The difference between the proposed algorithm and the known ones lies in taking into account a greater number of factors affecting the effectiveness of the functioning of the system of democratic civilian control over the security and defense sector. This makes it possible to increase the efficiency of the decisions made regarding the state of the system of democratic civilian control over the security and defense sector due to:

– sequential solution of forward and reverse planning problems using simulation modeling of the dynamics of the system of democratic control over the state of the system of democratic civilian control over the security and defense sector;

– providing a set of development trajectories of the system of democratic civilian control over the security and defense sector at each phase;

– analysis of possible options for the development of the system of democratic civilian control over the security and defense sector in each phase of development and moments in time when it is necessary to carry out structural changes that ensure the transition to the next phase. At the same time, subjective factors of choice (advantages of the decision maker) are taken into account while searching for solutions, which are formalized in the form of weighting coefficients for the components of the integral efficiency criterion. The maximization of the criteria, calculated taking into account the advantages, makes it possible to determine the best option for the development of the system of democratic civilian control over the security and defense sector;

– taking into account the uncertainty about the state of the democratic civilian system control over the security and defense sector;

– reduction of the space of features subject to priority evaluation from the set of available ones.

2. The proposed architecture of the information system of democratic civilian control over the security and defense sector. The effectiveness of the information system was assessed using the proposed method. It was established that its efficiency is 40 % higher, compared to the methods used to evaluate the effectiveness of the decisions made.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research, including financial, personal, authorship, or any other, that could affect the research and its results presented in this article.

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Availability of data

The manuscript has associated data in the data repository.

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