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IMPROVEMENT OF THE OPTIMIZATION METHOD BASED ON THE WOLF FLOCK ALGORITHM

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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 hierarchical nature of the object. The object of the research is decision making support system. The subject of the research is the decision making process in management tasks using an improved wolf flock algorithm. The hypothesis of the research is to increase the efficiency of decision making with a given assessment reliability. In the course of the research, an improved optimization method based on an improved wolf flock algorithm was proposed. In the course of the conducted research, the general provisions of the theory of artificial intelligence were used to solve the problem of analyzing the objects state and subsequent parametric management in intelligent decision making support systems.

The essence of the improvement lies in the use of the following procedures, which improve basic procedures of the wolf flock algorithm, namely search and chase:

– taking into account the type of uncertainty of the initial data while constructing the wolf flock path metric;

– searching for a solution in several directions using individuals from the wolf flock;

– initial presentation of individuals from the wolf flock;

– an improved procedure for adapting a flock of wolves;

– taking into account the available computing resources while choosing the number of leaders in a flock of wolves.

An example of the use of the proposed method is presented on the example of assessing the state of the operational situation of a group of troops (forces). The specified example showed an increase in the efficiency of data processing at the level of 23–30 % due to the use of additional improved procedures

Keywords: artificial intelligence, wolf flock algorithm, data uncertainty, evaluation efficiency, adaptability

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1. Introduction

Computational intelligence methods have become widespread for solving a variety of complex tasks, both purely scientific and in the field of technology, business, finance, medical and technical diagnostics, and other fields. These include intelligent data analysis (Data Mining), dynamic data analysis (Dynamic Data Mining), analysis of data streams (Data

Stream Mining), analysis of large data sets (Big Data Mining), Web-Mining, Text Mining, etc. [1–6].

The increase in the volume of information circulating in various systems of information collection, processing and transmission leads to a significant use of computing resources of hardware. The armed forces of technically developed countries have integrated decision making architectures based on [7–15]:

– artificial intelligence and nanotechnologies;

– effective processing of large amounts of information;

– data compression technologies to increase the speed of their processing.

The use of information systems with elements of artificial intelligence will allow to increase the efficiency of planning, conducting operations (combat operations) and their comprehensive support and also will affect the doctrine, organization and methods of application of groups of troops (forces) [7–15].

The analysis of researches [1–15], the experience of wars, armed conflicts of the last decades and the experience of full-scale armed aggression of the Russian Federation on the territory of Ukraine shows that the dynamics of operations (combats), the increase in the number of various sensors and the need to integrate them into a single information space creates a number of problems:

– implemented algorithms for establishing correlations between events do not fully take into account the reliability of sources of intelligence information and the reliability of information in the dynamics of operations (combats);

– forms of information presentation complicate its transmission through communication channels;

– limited computing power of hardware;

– radio electronic suppression of SW and USW radio communication channels and cybernetic influence on information systems;

– transition to the principle of monitoring objects assessment «everything affects everything at once», which covers the aggregate network and computing resources of all types of armed forces.

That is why it is necessary to develop algorithms (methods and techniques) that are able to solve optimization problems from various sources of intelligence information in a limited time and with a high degree of reliability and to conduct a simultaneous search for solutions in several directions.

Taking into account the above, an urgent scientific task is to improve the optimization method based on the wolf flock algorithm, which would allow to increase the efficiency of the decisions made regarding the management of the parameters of the control object with the given reliability.

2. Analysis of literary data and formulation of the problem

The work [9] presented a cognitive modeling algorithm. The main advantages of cognitive tools are defined. The lack of consideration of the type of uncertainty about the analysis object state should be attributed to the shortcomings of this approach.

The work [10] revealed the essence of cognitive modeling and scenario planning. A system of complementary principles of building and implementing scenarios is proposed, different approaches to building scenarios are highlighted, the procedure for modeling scenarios based on fuzzy cognitive maps is described. The approach proposed by the authors does not allow to take into account the type of uncertainty about the analysis object state and does not take into account the noise of the initial data.

The work [11] carried out an analysis of the main approaches to cognitive modeling. Cognitive analysis allows: to investigate problems with unclear factors and relationships; to take into account changes in the external environment and use objectively formed trends in the development of the situation in one's interests. At the same time, the issue of describing complex and dynamic processes remains unexplored in this work.

The work [12] 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 lack of taking into account the type of uncertainty of the input data.

The work [13] presents 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 shortcomings of the mentioned approach include the impossibility of assessing the adequacy, reliability of the information transformation process and appropriate correction of the obtained models.

The work [14] developed an analytical web-platform for the research of geographical and temporal distribution of incidents. Web-platform, contains several information panels with statistically significant results by territory. The disadvantages of the specified analytical platform include the impossibility of assessing the adequacy, reliability of the information transformation process and high computational complexity. Also, one of the shortcomings of the mentioned research should be attributed to the fact that the search for a solution is not unidirectional.

The work [15] 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. The disadvantages of the specified method include the impossibility of assessing the adequacy and reliability of the assessment and, accordingly, determining the assessment error.

The work [16] carried out an analysis of 30 algorithms for processing large data sets. Their advantages and disadvantages are shown. It was established that the analysis of large data sets should be carried out in layers, take place in real time and have the opportunity for self-learning. Among the disadvantages of these methods should be attributed their high computational complexity and the impossibility of checking the adequacy of the obtained estimates.

The work [17] presents an approach for evaluating input data for decision making support systems. The essence of the proposed approach consists in the clustering of the basic set of input data, their analysis, after which the system is trained based on the analysis. The disadvantages of this approach are the gradual accumulation of assessment and training errors due to the lack of an opportunity to assess the adequacy of the decisions made.

The work [18] presents an approach to data processing from various sources of information. This approach allows to process data from various sources. The disadvantages of this approach include the low accuracy of the obtained estimate and the impossibility of verifying the reliability of the obtained estimate.

The work [19] carried out a comparative analysis of existing decision making support technologies, namely: the method of analyzing hierarchies, neural networks, the theory of fuzzy sets, genetic algorithms and neuro-fuzzy modeling. The advantages and disadvantages of these approaches are indicated. The spheres of their application are defined. It is shown that the method of analyzing hierarchies works well under the condition of complete initial information, but due to the need for experts to compare alternatives and choose evaluation criteria, it has a high share of subjectivity. For forecasting problems under conditions of risk and uncertainty, the use of the theory of fuzzy sets and neural networks is justified.

The work [20] developed a method of structural and objective analysis of the development of weakly structured systems. An approach to the research of conflict situations caused by contradictions in the interests of subjects that affect the development of the studied system and methods of solving poorly structured problems based on the formation of scenarios for the development of the situation. At the same time, the problem is defined as the non-compliance of the existing state of the system with the required one, which is set by the management entity. At the same time, the disadvantages of the proposed method include the problem of the local optimum and the inability to conduct a parallel search.

The work [21] presents a cognitive approach to simulation modeling of complex systems. The advantages of the specified approach, which allows to describe the hierarchical components of the system, are shown. The shortcomings of the proposed approach include the lack of consideration of the system computing resources.

The work [22] indicated that the most popular evolutionary bio-inspired algorithms are the so-called «swarm» procedures Particle Swarm Optimization (PSO). Among them, there is a «flock of wolves» search algorithm – a metaheuristic algorithm for finding the global minimum of a function, which is very promising from the point of view of speed and ease of implementation. As it can be seen from the name, the idea of the algorithm is based on natural factors.

Wolves have a typical family lifestyle: they live in flocks – family groups consisting of a pair of leaders, their relatives and lone wolves. A strictly defined hierarchy is observed within the flock, at the top of which is the flock leader, who directs other individuals to search for prey. Wolves «explore» the area for the presence of a victim, when one of them smells the victim, the search for it begins. The stronger the smell, the closer the wolves are to the prey. Thus, they move in the direction of increasing the smell of the victim.

The «flock of wolves» search method copies the process of their hunting. Let's suppose that the area on which wolves hunt is a search area in the sense of optimization and the flocks are wolves. At the same time, these procedures have some shortcomings that worsen the properties of the global extremum search process.

An analysis of works [9–22] showed that the common shortcomings of the above-mentioned researches are:

– the lack of possibility of forming a hierarchical system of indicators;

– the lack of consideration of computing resources of the system;

– the lack of mechanisms for adjusting the system of indicators during the assessment;

– the lack of consideration of the type of uncertainty about the management object state, which creates corresponding errors while assessing its real state;

– the lack of deep learning mechanisms of knowledge bases;

– a high computational complexity;

– the lack of consideration of computing (hardware) resources available in the system;

– the lack of search priority in a certain direction.

The problem that needs to be solved in the research is increasing the efficiency of solving optimization problems while ensuring the given reliability.

For this purpose, it is proposed to improve the method of parametric optimization based on the improved wolf flock algorithm.

3. The aim and objectives of the research

The aim of research is an improvement method of parametric optimization based on the improved wolf flock algorithm. This will allow to increase the efficiency of optimization with a given reliability and the development of subsequent management decisions. This will make it possible to develop software for intelligent decision making support systems in the interests of the combat management of the actions of troops (forces).

To achieve the aim, the following objectives were set:

– to carry out a mathematical formulation of the research task;

– to determine the method implementation algorithm;

– to give an example of the application of the proposed method in the analysis of the operational situation of a group of troops (forces).

4. Research materials and methods

Problem, which is solved in the research, is to increase the efficiency of decision making in management tasks while ensuring the given reliability, regardless of the hierarchical nature of the object. The object of research is decision making support systems. The subject of the research is the decision making process in management tasks using the wolf flock algorithm. The hypothesis of the research is to increase the efficiency of decision making with a given assessment reliability.

The methods of the theory of artificial intelligence were chosen as the main research methods. This is due to the need to process various types of data that have different origins and units of measurement, and the possibility of finding solutions in several directions. The authors took the wolf flock method as a basis and improved it.

The simulation was carried out using MathCad 2014 software (USA) and an Intel Core i3 PC (USA). The assessment of elements of the operational situation of the group of troops (forces) was the task to be solved during the simulation.

The operational grouping of troops (forces) was considered as an object of assessment and management. An operational grouping of troops (forces) formed on the basis of an operational command with a typical composition of forces and devices according to the wartime staff and with a range of responsibility in accordance with current regulations.

5. Research results on the development of a parametric optimization method based on an improved wolf flock algorithm

5. 1. Mathematical formulation of the task of optimization research based on the improved wolf flock algorithm

It is given: $I=\{1,..., n\}$ is the set of points, matrix (c_{ij}) is the pairwise distances between points $1\leq i, j\leq n$.

Let's find: a contour (path) of minimum length, thus, a cycle that passes through each vertex exactly once and has minimum weight.

Let's carry out a mathematical formulation of the parametric optimization task using the wolf flock algorithm:

Variable tasks: $x_{ij}=\begin{cases}1,\text{if we have path,}\\0,\text{other.}\end{cases}$

Find the objective function of the form:

$$J(x)=\min\sum_{i=1}^{N}\sum_{j=1}^{N}c_{ij}x_{ij}, \quad (1)$$

where c_{ij} is the distance between points i and j under the following restrictions:

$$\sum_{j=1}^{N}x_{ij}=1,\forall j=\overline{1,N},\ \sum_{i=1}^{N}x_{ij}=1,\forall i=\overline{1,N}. \quad (2)$$

Let N «wolves» be generated in the Euclidean space of dimension D, thus, each wolf is represented in the form of a vector x_i (x_{i1},..., x_{iD}), which determines its coordinates in space. Thus, the swarm (population) represents a set of potential solutions, the coordinates of which, just as for the swarm optimization algorithm [2], are updated at each iteration until the optimal solution is found or the maximum set number of calculations of the objective function is performed.

Then the function $f(x)$, which characterizes how strongly the smell of the victim is felt by wolves, is the target, and the coordinates of the victim itself are the optimal point. The distance between two wolves p and q is described by the species metric: $L(p,q)$).

The «flock of wolves» algorithm searches for the optimal victim point. They divide into groups, move in different directions and exchange information among themselves.

5. 2. Improvement of the optimization algorithm based on a flock of wolves

The optimization algorithm based on a flock of wolves consists of the following sequence of steps.

Step 1. Input of output data.

At this stage, the initial data available in the system are entered to solve the optimization problem.

Step 2. Placing wolves in initial positions taking into account uncertainty.

Create a flock of wolves in the form of a set of Euclidean vectors distributed over a set of admissible values of arguments, taking into account the degree of χ awareness of the object state. Division of the degree of uncertainty: (full uncertainty – exposure randomly, partial uncertainty – exposure taking into account the correction factor for the position of wolves χ=0.01÷0.99).

Step 3. Determination of leaders in the flock.

In the classical wolf flock algorithm, the «wolf» with the best value of the objective function at this iteration is the leader. If at the next iteration another «individual» is found with a better value of the objective function than that of the leader, then, accordingly, the flock «finds» a new leader. In the specified procedure, it is proposed to determine the number of leaders that will ensure the maximization of the efficiency of the search with limitations on the available computing resources.

Step 4. Search for prey by other wolves of the flock.

Other wolves explore the area for prey. Moreover, the function $f(x_i)$ characterizes how strongly the smell of the victim is felt by the i-th «wolf». Then the value of G_{best} characterizes how strongly the smell of the victim is felt by the flock leader.

Step 5. Change of leader in the flock.

If $f(x_i)>G_{Best}$, then the i-th «wolf» is closer to the victim than the leader of the flock, so the i-th wolf becomes the leader at this stage $f(x_i)=G_{Best}$. If $f(x_i)<G_{Best}$, then the «wolf» moves in space with some predetermined step.

The leader(s) of the flock «inform» the other «wolves» in the flock about their location, as the closest point to the victim now, so that they move in its direction.

Step 6. Approaching the flock leaders.

At this stage, the «leader» is considered almost the same as the victim – a goal to which it is necessary to approach. Then the «wolves» of the flock move in the direction of the leader with a predetermined step and the coordinate d i-th «wolf» on the $(k+1)$-th iteration is calculated by the formula:

$$x_{iD}^{(k+1)}=x_{iD}^{(k)}+step\frac{G_{Best}^{(k)}-x_{iD}^{(k)}}{\left\|G_{Best}^{(k)}-x_{iD}^{(k)}\right\|}. \quad (3)$$

From formula (3) and the description of the algorithm, it can be seen that in the «flock of wolves» search method, only the coordinates of the «wolves» are updated without taking into account the speed of their movement in space. Four parameters must be selected for the swarm algorithm (learning coefficients, inertial weight, population size). However, for the wolf flock search method, it is enough to choose only two parameters – the population size N and the step, from which the «wolves» move in the direction of the leader and the victim. It should be noted that formula (3) cannot be applied to the traveling salesman problem in a standard way.

In this case, only its main principle is taken, namely: other «wolves» must be sufficiently «similar» to their leader(s), who in the current iteration is closer to the victim (by the value of the objective function). At this stage, using the improved genetic algorithm proposed by the authors in the work [23].

Let there be a population and a corresponding adaptation of each wolf. An example of the algorithm is shown in Tables 1–3.

Then, let's determine the best «wolf» by its value of the adaptation function (Table 2).

Table 1

An example of «wolf chromosomes» with the value of adaptability

Chromosomes (the order of passing points by a traveling salesman)						The value of the adaptation function (passed by the corresponding «wolf»)
3	1	6	4	2	5	0.31
5	6	2	1	3	4	0.32
3	4	2	5	1	6	0.021
4	1	6	2	5	3	0.32

Table 2

The best chromosome of the population

The best chromosome						Value of the adaptation functions
3	4	2	5	1	6	0.0263

Based on the best chromosome (Table 2), let's generate a new population based on the work [23] (Table 3).

Table 3

Generation of a new population based on the wolf with the best adaptation (by the length of the made path)

Chromosomes (order of passing points)						The value of the adaptation function (the made path by the corresponding wolf)
3	4	2	5	1	6	0.022
2	3	4	5	1	6	0.19
3	4	2	5	6	1	0,04
1	4	2	5	6	3	0,21

All subsequent iterations are performed in a similar way: the best «wolf» is found and a new population is generated based on it.

End of algorithm.

5. 3. An example of the application of the proposed method while analyzing the state of an operational group of troops (forces)

Initial data for optimization of decision making regarding the state of the operational grouping of troops (forces) using the proposed method:

– the number of sources of information about the operational grouping of troops (forces) is 3 (radio monitoring tools, remote sensing of the earth and unmanned aerial vehicles). To simplify the modeling, the same number of each tool was taken – 4 tools each;

– the number of informational signs by which the state of the operational grouping of troops (forces) and parametric management is determined – 200. Such parameters include: affiliation, type of organizational and staff formation, priority, minimum width along the front, maximum width along the front. The number of personnel, the minimum depth along the flank, the maximum depth along the flank, the total number of personnel, the number of WME samples, the number of types of WME samples and the number of communication devices) are also taken into account;

– the variants of organizational and personnel formations are company, battalion, brigade.

The comparative analysis of the obtained work results was carried out on the basis of two criteria: the criterion of time and the criterion of the optimal distance traveled by the traveling salesman found by each algorithm for a different number of points (from 30 to 300). Tabular results are given below (Tables 4, 5).

Let's compare how effective the modification of this algorithm is compared to population algorithms, such as «particle swarm» optimization and the classic genetic algorithm, which is most often used to solve the traveling salesman problem (Tables 6, 7).

Table 4

Comparative analysis of the classical and modified «flock of wolves» algorithm for the traveling salesman problem according to the criteriondistance objective function

The number of vertices	Population size	Maximum number of iterations	The classic type wolf flock algorithm		Modified wolf flock algorithm		Accurate solution to a minimum
			f_{Best}	The % of the error	f_{Best}	The % of the error	
30	30	1000	23.95767	1.2 %	21.4	0.00 %	23.584849
50	60	5000	429.5757	1.25 %	416.2	0.1 %	421.787667
100	100	10000	534.5848	1.7 %	520.7	1.16 %	523.584849
150	200	20000	312.7	2.28 %	308.2	1.22 %	328.087454
300	500	50000	881.8	3.75 %	846.5	1.5 %	854.154940

Table 5

Comparative analysis of the classic and modified wolf flock algorithm for the traveling salesman problem according to the criterion of working time

The number of vertices	Population size	Maximum number of iterations	Algorithm operation time (in seconds)	
			The classic type wolf flock algorithm	Modified wolf flock algorithm
30	30	1000	2.15978	1.8
50	60	5000	10.79888	11.6
100	100	10000	53.99440	50.1
150	200	20000	269.97198	270.3
300	500	50000	1349.85991	1355.24

Table 6

Comparative analysis of the modified «flock of wolves» algorithm with the genetic algorithm and the particle swarm algorithm based on the criterion of the optimal made path

The number of vertices	Population size	The classic algorithm of swarm particles		Classical genetic algorithm		Modified wolf flock algorithm		Exact solution to a minimum
		f_{Best}	The % of the error	f_{Best}	The % of the error	f_{Best}	The % of the error	
30	30	24.78769	5.10 %	24.48957	3.84 %	23.12	0.00 %	23.584849
50	60	431.75587	2.36 %	428.76556	1.65 %	411.9	0.11 %	421.787667
100	100	538.56887	2.86 %	538.85479	2.92 %	524.4	1.2 %	523.584849
150	200	338.66566	3.22 %	334.77659	2.04 %	312.4	1.36 %	328.087454
300	500	902.66575	5.68 %	887.56746	3.91 %	850.6	1.7 %	854.154940

Table 7

Comparative analysis of the modified wolf flock algorithm with the genetic algorithm and the particle swarm algorithm according to the criterion of working time

The number of vertices	Population size	Maximum number of iterations	Algorithm operation time (in seconds)		
			The classic algorithm of swarm particles	Classical genetic algorithm	Modified wolf flock algorithm
30	30	1000	2.74546	2.43579	1.33
50	60	5000	11.64576	18.85740	11.83
100	100	10000	53.65869	61.27783	50.7
150	200	20000	269.76457	271.19442	260.1
300	500	50000	1349.57659	1356.37387	1298.7

6. Discussion of the results of the development of the optimization method based on the wolf flock algorithm

The obtained results on increasing the efficiency of the optimization are explained by the use of the improved wolf flock algorithm in contrast to the classical empirical expressions and the classical wolf flock algorithm. The wolf flock algorithm is not used in its classical form, but by improving it with the help of improved procedures for exhibiting wolves, taking into account the type of uncertainty and additional use of additional procedures developed by the authors in the work [23].

The main advantages of the proposed optimization method based on a flock of wolves are:

– it has a flexible hierarchical structure of indicators, which allows to reduce the task of multi-criteria evaluation of alternatives to one criterion or use expressions in comparison with works to select a vector of indicators [12–14];

– unambiguousness of the obtained solution (1)–(3) in comparison with works [16, 17];

– universality of application due to the adaptation of the system of indicators in the course of work in comparison with works [12–14];

– taking into account the type of uncertainty of the initial data while constructing the wolf flock path metric in comparison with work [22] (step 2);

– high reliability of the obtained solutions while searching for a solution in several directions using individuals from a flock of wolves, due to the selection of several leaders (step 3) in comparison with work [22];

– the possibility of finding a solution in several directions in comparison with works [9–15, 17–21];

– improved procedure of adaptation of wolves (Tables 1–3) in comparison with work [22].

The disadvantages of the proposed method include:

– lower accuracy of assessment and parametric control for a single parameter compared to work [14];

– the loss of credibility of the obtained solutions while searching for a solution in several directions at the same time in comparison with works [12–14].

This method will allow:

– to assess the object state and its parametric management;

– to determine effective measures to improve management efficiency;

– to increase the speed of assessing the object state and making management decisions regarding the management of its parameters;

– to reduce the use of computing resources of decision making support systems.

The proposed method allows solving the task of increasing the efficiency of the optimization process with its parameters due to the synthesized wolf flock algorithm.

The modified wolf flock algorithm gives more accurate results in contrast to the classical one, while the accuracy increases to 30 %, but the working time of the modified algorithm is 10 % longer. This is due to the fact that the entire population is divided into subgroups, each of which has its own «leaders». According to the results given in the table 5, it can be seen that the working time of the modified algorithm is on average 20 % less than that of the «particle swarm» algorithm from those given in the Table 7. The main working time of the genetic algorithm is devoted to cross-breeding and obtaining pairs of chromosomes.

This method is advisable to use in decision making support systems to optimize decision making as a software product. It is proposed to be used in the interests of combat management of the actions of troops (forces).

The limitations of the research are:

– the need to know the completeness of information about the state of the control object for determining the correction coefficients;

– the need to know the number of computing resources of the decision making support system.

It is advisable to use the proposed approach to solve the problems of evaluating complex and dynamic processes and their parametric control, which are characterized by a high degree of complexity.

This research is a further development of researches aimed at the development of methodological principles for increasing the efficiency of information and analytical support, which were published earlier [2, 4–6, 23–37].

The directions of further research should be aimed at reducing computing costs while processing various types of data in special purpose systems.

7. Conclusions

1. A mathematical formulation of the research task was carried out with the help of a flock of wolves. The proposed mathematical statement of the research task allows to formulate a mechanism for solving the optimization problem using the wolf flock algorithm during the management of hierarchical objects.

2. The method implementation algorithm is defined, which allows:

– to take into account the uncertainty data type due to the decomposition of the input uncertainty type of the corresponding correction coefficient;

– to take into account the available computing resources of the management object state analysis system while determining the number of individuals and leaders in a flock of wolves;

– to increase the efficiency of adaptation of a flock of wolves with the help of an improved genetic algorithm, developed in the work [23];

– to carry out the initial display of individuals of a flock of wolves taking into account the type of uncertainty due to the decomposition of the type of uncertainty and the introduction of the appropriate correction coefficient.

3. Conducted example of using the proposed method on the example of assessing the state of the operational situation of an army (force) grouping. The conducted simulation showed that the obtained modification of the method of searching by a flock of wolves better solves the task of state analysis and parametric control with different input data to the traveling salesman problem than the classical algorithm of searching by a flock of wolves. It also showed better results compared to well-known algorithms for solving this problem, such as the genetic algorithm and the particle swarm algorithm.

The specified example showed an increase in the efficiency of data processing at the level of 23–30 % due to the use of additional improved procedures. The obtained data made it possible to conclude that the time complexity of the algorithm does not exceed the polynomial complexity.

Conflict of interest

The authors declare that they have no conflict of interest in relation to the 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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