Automated Assessment Of The Air Situation During The Preparation And Conduct Of Combat Operations Using A Decision Support System Based On Fuzzy Networks Of Target Installations

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Summary
The article considers the improved method and model of automated air situation assessment using a decision support system based on fuzzy networks of target installations. The advanced method of automated assessment of the air situation using the decision support system is based on the methodology of reflexive control of the first rank. With this approach, the process of assessing the air situation in the framework of the formulated task can be reduced to determining the purpose, probabilistic nature of actions and capabilities of the air target. The use of a homogeneous functional network for the formal presentation of air situation assessment processes will formally describe the process of determining classes of events during air situation assessment and the process of determining quantitative and qualitative characteristics of recognized air situation situations. To formalize the patterns of manifestation of the values of quantitative and symbolic information, it is proposed to use the mathematical apparatus of fuzzy sets.
Keywords:
formalization, method, network model, target installation, air situation assessment, decision support system

1. Introduction

An important condition for effective is a reasonable and timely assessment of the air situation [1]. Increasing dynamism and ephemerality, a high degree of uncertainty, tight time frames for assessing the air situation and the need to analyze and take into account a large number of heterogeneous factors indicate the need to automate the process of solving the problem [2].

Analysis of algorithms of special mathematical software (SMS) of automation systems (ACS) allows us to state that the processes of making decisions on the assessment of the air situation are insufficiently automated. This leads to the fact that the assessment of the air situation is carried out either only on the basis of subjective decisions of decision makers, or using information models to solve partial calculation problems that do not fully take into account the complexity of dynamic air conditions [3-5].

Ensuring the necessary level of automation of air situation assessment processes is complicated by the fact that in the course of work they use mainly their own knowledge and experience, which are difficult to formalize with the use of traditional information technologies.

One of the promising areas of automation of air assessment processes is the improvement of mathematical and software based on new information technologies, which include, for example, modern network technologies, methods of distributed information processing, expert systems technology, etc. [6].

At present, the level of development of science and technology is characterized by increased opportunities in the creation and application of specialized information systems - decision support systems.

The decision support system (DSS) can be both simple in its functions, implementing the functions of collecting information and presenting it to the operator in a formalized form, and complex, providing ATS, information-analytical models and multivariate solutions that change with changing air conditions. Methods of decision support along with information-analytical models [7].

The analysis of the existing methods and models of air situation assessment [4-7] shows that none of them can provide the necessary level of formalization of air situation assessment processes. Thus, there is a need for additional research. In this case, some of the methods, in the case of expanding their descriptive capabilities, can be taken as the basis for building a single formal and logical apparatus of knowledge about the processes of assessing the air situation. These include: methods of knowledge representation based on logical models of knowledge; methods based on the mathematical apparatus of the

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theory of fuzzy measures and sets; network models of target installations.

2. Theoretical Consideration

The process of assessing the air situation can be reduced to the assessment of many events (situations) Ω_t, occurring at one point in time *t*.

At the planning stage, an appropriate set of events is identified, which determines the probabilistic nature of the action [3]:

$$\hat{\Omega}_t = \left\{\hat{S}_i^{\text{план}}\right\},$$

where $S_i^{\text{план}}$ – events planned at the planning stage;

i – event number (*i* = 1, ..., *I*);

I – number of events.

These events are described by a system of reference values of the emerging features $\left\{\text{Пр}_j^{\text{етал}}\right\}$, where *j* – sign number (*j* = 1, ..., *J*); *J* – the number of features used to describe the event:

$$\Omega_t = \left\{S_i^{\text{поточ}}\right\},$$

where $S_i^{\text{поточ}}$ – events that characterize the current air situation, which is described by a system of signs $\left\{\text{Пр}_j^{\text{поточ}}\right\}$, coming from sources of information.

Assessment of the air situation is to establish a correspondence between $S_i^{\text{план}}$, $S_i^{\text{поточ}}$. This problem can be solved by determining the degree of compliance of the reference and current values of the features that describe, respectively, the set of planned and current situations.

Each event can be formally represented as a set of initial conditions:

$$S_i = \{N_k\}_{k=1,\dots,K} \in \Omega,$$

where N_k – initial condition,

k – номер початкової умови,

N_k – the number of initial conditions describing the event S_i.

The initial condition is a formal description of situations (events) or states of the objects of the problem area, which determines the set of necessary and sufficient conditions for the implementation of decision-making procedures. This set of situations, events, objects is interpreted at a certain point in time t. Assuming that each of the initial conditions is a formal representation of an event, a subset of each PU will determine one of the probable options for enemy action identified at the combat planning stage. Then the whole set of initial conditions allows to formally represent the whole process of assessing the air situation. The implementation of such a process can be reduced to determining the pragmatic truth of the relevant initial conditions.

Analysis of the content of the processes of assessing the situation allows us to identify the main types of tasks: logical-analytical, computational and exploratory [4]. If each of the types of problems is brought to the corresponding class, then the methods of solving these problems can be presented as methods of determining the pragmatic truth of the corresponding. Thus, according to the methods of determining pragmatic truth, we can introduce the following classification:

1) functional - implement solutions to problems of logical and analytical nature;

2) estimated - require calculations to determine the quantitative characteristics of situations;

3) search - require the organization of search and retrieval of information from the database.

Given the nature of problem solving in determining the pragmatic truth of the initial conditions, formally can be represented as the following tuple:

$$N_k = \left\langle S_k, T_k, Pr_k, \overline{P}_k, R_k \right\rangle, \quad (1)$$

where S_k – semantic description;

T_k – type;

Pr_k - the procedure for determining pragmatic truth;

$\overline{P}_k$ – the set of source data for the description;

R_k – the result of the description.

In turn, the results of the description may be: some Boolean function that takes the meaning of "truth" ("not true"); the value of the function obtained by calculation or search.

Thus, the task of improving the method of automated assessment of the air situation is:

- to the formal presentation of the rules for determining the pragmatic truth of the initial conditions;
- to the formal presentation of the rules for determining the pragmatic truth of symbolic information;
- to the formal submission of air situation assessment processes.

The task of assessing the air situation is to assign events to a specific class of the alphabet, defined at the planning stage of hostilities.

Under the alphabet of classes A_L we will understand a subset of disparate classes that describe an event (object) in the process of assessing the situation:

$$\mathrm{A}_L = \{k_1, k_2, ..., k_n\},$$

where L – the number of possible alphabets of classes when describing the air situation ($L = \overline{1, s}$);
n – number of classes in the alphabet.
The following requirements are set for the construction of class alphabets:
- event classes cannot belong to two or more alphabets at the same time;
- combining classes into alphabets should be based on a set of essential features;
- The alphabet must fully describe one object (situation) of the subject area.
By class we mean an arbitrary set of objects that are characterized by any set of properties or characteristics (a set of common properties, characteristics) [5].
Given the peculiarities of the process of assessing the air situation, a formalized description of classes can be built using information from sources of features, in the methodology of reflexive management of the first rank [6]. In this case, the description of a class can be represented as an expression:

$$k = \bigcup_{i=1}^{I} \bigcap_{j=1}^{J} X_{ij}, \quad (2)$$

X_{ij} – determines the sign of the parameter that determines the property;
I – number of properties (features);
i – property number (attributes);
J – the number of property values (features),
j – property value number (attributes).
When constructing classes should take into account the fact that the number of features that characterize this class can be virtually unlimited. Therefore, the following requirements must be met:
- a set of features should be necessary and, at the same time, sufficient to describe the situation in the process of assessing the air situation;
- a set of features should allow the most complete representation of the problem area model for implementation.
Analysis of the possibilities of known methods of formalization indicates the feasibility of using homogeneous functional networks for a formalized description of logical and analytical problems solved by the LPR in the process of assessing the air situation. Functional network is an oriented graph in which arcs reflect the functional dependence of vertices on the levels of hierarchy, and the description of vertices specifies the process of obtaining the result on the values of arguments [7, 8].
Formally, a functional network can be represented by a tuple of the following type:

$$F = \langle I_1, I_2, ..., I_n; \mathrm{C}; \Gamma \rangle, \quad (3)$$

where $I_1, I_2, ..., I_n$ – set of vertices;
C – type of relationship between vertices;
Γ – mapping the set of network vertices to the set of relationships.
According to expression (2), the process of forming descriptions of events in the assessment of the air situation can be represented by a certain logical chain of features and a set of operations on the obtained sets. The following types of vertices can be used to formalize evaluation processes:

1. The set of initial vertices of the network $\{X_j\}$ – vertices, the content of which determines the original links (current values $\{\text{Пр}_j^{\text{поточ}}\}$ and reference features $\{\text{Пр}_j^{\text{етал}}\}$) to solve the problem of comparing the current and reference event:

$$\{\text{Пр}_j\}_{j=1...J} = \{\{\text{Пр}_j^{\text{етал}}\}, \{\text{Пр}_j^{\text{поточ}}\}\}.$$

2. The set of vertices of comparison $\{S_j\}$ – vertices for determining the degree of closeness of the reference and current distributions of values of the same characteristics:

$$\{S_j\}_{j=1...J} = \{f_j\left(\text{Пр}_j^{\text{етал}}, \text{Пр}_j^{\text{поточ}}\right)\},$$

where $f_j\left(\text{Пр}_j^{\text{етал}}, \text{Пр}_j^{\text{поточ}}\right)$ – the function of determining the degree of closeness of the reference and current distributions of the values of the same characteristics.

3. Many conjunctival $\{K_\gamma\}$ and disjunctive $\{D_\beta\}$ vertices corresponding to the operations of conjunction and disjunction of the results of comparisons of the reference and current distributions of the values of the features, where

$$\{K_\gamma\}_{\gamma=1...\Gamma} = \bigcap_{\gamma=1}^{\Gamma} \mathrm{f}_\gamma\left(\text{Пр}_\mathrm{j}^\mathrm{e}, \text{Пр}_\mathrm{j}^\mathrm{т}\right),$$

$$\{D_\beta\}_{\beta=1\ldots B}=\bigcup_{\beta=1}^{B} f_\beta\left(\text{Пр}_j^e,\text{Пр}_j^T\right),$$

$\Gamma + B = Z$ – the number of conjunctive and disjunctive vertices on the network.

4. The top of the event class definition k_n^* – the top of the network that implements the crucial rule for determining the event class:

$$k_n^*=\bigcup_{i=1}^{I}\bigcap_{j=1}^{J}X_{ij}$$

5. Many parametric vertices $\{\dot{P_n}\}$ – vertices of quantitative determination $\{V_n\}$ and quality $\{W_n\}$ characteristics of recognized classes of situations:

$$\{P_n\}_{n=1\ldots N}=\{\{V_n\},\{W_n\}\}.$$

6. Target top of the network, which determines the type of event that occurred during the assessment of the air situation and its characteristics:

$$\text{Ц}=\langle k_n,\{V_n\},\{W_n\}\rangle.$$

Thus, the model for assessing the air situation can be represented as:

$$\text{M}_{\text{о.п.об}}=\left\langle\{\text{H}_j\},\{S_j\},\{\text{K}_\gamma\},\{D_\beta\},\text{k}_n^*,\{\text{P}_n,\text{Ц}\}\right\rangle.$$

For the formal representation of the regularities of the manifestation of the values of quantitative and symbolic information, it is proposed to use the mathematical apparatus of fuzzy sets. Given the adopted approach to the probabilistic nature, it is advisable to introduce some function that characterizes the informativeness of the features in the evaluation of such options. The membership function is used as such a function $\mu(x)$, the area of definition of which is on the interval [0, 1].

Conclusions

Based on the above material, we can say that the tasks that life sets before us in the field of education will be solved with the help of various pedagogical innovations. The theoretical justifications for the introduction of new educational technologies are set out quite clearly; they are also based on the psychological characteristics of the age of students.

An analysis was made of the experience of leading scientists who teach using various technologies and the traditional school. In the work on the theoretical material, a diagnosis of the level of education quality was carried out and a comparative description of the innovative and traditional methods was given.

But based on the materials of publications assessing the level of knowledge quality, it can be said with confidence that the more pedagogical innovations are used in our country, the more developed students will be and leaders and teachers will become familiar with the processes of introducing innovations.

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