Secure processing of visual information in the automated optoelectronic system of ground-space monitoring

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Abstract: **The main approaches to the development of an automated optoelectronic system of ground-space monitoring, providing secure processing of visual information under conditions of information competition, are considered. The achievements have theoretical and practical value when solving the problem of information performance provision in different areas of interests demanding visual information processing.**

Keywords: protected processing of privileged visual information; efficiency; accuracy; information competition

I. Introduction

Global informatization and information competition stipulate for introduction of a rational methodology of building efficient automated optoelectronic system of ground-space monitoring (AOES GSM) having high values of accuracy, promptness, reliability, stability, survivability, as well as a high degree of information security to ensure functioning in an aggressive information environment. One of the central problems in the field of automated image processing is ensuring high precision of solving specific tasks resistant to various detrimental aggressive factors, with a clearly defined and studied range of application.

The development of the effective AOES seems possible through the use of a problem-oriented version of the integrated ICSD-approach ("informational-cybernetic-synergetic-didactic") [1], i.e. a systematic approach with emphasis on its informational, cybernetic, synergetic and didactic aspects, which consists in integrating the methodology of the informational approach (when the object is considered as a goal-oriented information system), the methodology of the cybernetic approach (when the object is considered as a control system at the level of information processes and information base functioning algorithms) with the methodology of the synergetic approach (when the object is considered as a dynamic self-organizing system that interacts with the environment) and the methodology of the didactic approach (when the object is considered as a system capable of self-learning) as part of the methodology of the system approach (when the object is considered as a complex multi-level and multi-aspect system).

II. Conceptual-logical model and main tasks of AOES GSM

The well-known invariant functional structure can be used as a conceptual-logical model of AOES GSM (Fig. 1) [1,2].

This structure is presented as a complex of functional subsystems: measurement (P_1), observation (P_2), identification (P_3), management decision-making (P_4), centralized coordination (P_5), information exchange (P_6) and information protection (P_7) required for functioning under the conditions of information competition and ensuring the necessary protection in the course of information processing.

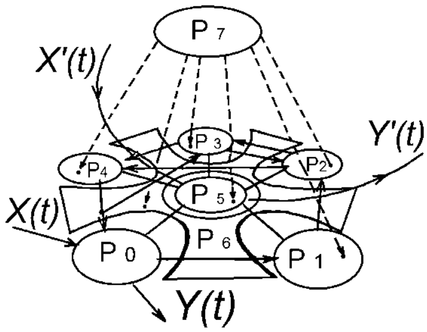

Figure 1. Conceptual-logical model AOES GSM

The object of management (P_0) receives various input actions at time t: functional R(t), external target X(t) and external coordinating X'(t), for which corresponding responses Q(t), Y(t), Y'(t) are formed.

The main tasks of AOES GSM are stabilization, detection, localization and classification of objects of interest in photo and video data in relation to various background-target situations. Difficulties in solving these problems arise due to the following: information losses when projecting a 3D scene (exposition) onto the image plane; presence of noise in the image; changes in the scene exposition; complex shapes of objects; changes in the object shape; partial or complete overlaps and obturations of scene objects; complex path of object motion; object goes beyond the frame boundaries or appears in the frame; relative motion of the camera; real-time processing requirements etc. [2,3]. The tasks of AOES GSM are distributed as follows according to functional subsystems: ensuring stabilization of video images - subsystem P_1 [4]; detection, localization and tracking - P_2 [5]; classification and selection - P_3 [6,7]; formation of control actions - P_4; design of learning samples and adjustment of system methods - P5 [8]; dynamic range compression and signal transmission [9] - P_6; crypto-conversion of signals - P_7.

III. Reorganization and mapping of multilevel AOES GSM on the conceptual-logical model

The reorganization scheme and mapping of the multilevel AOES GSM on the conceptual-logical model is presented in Fig. 2.

Reorganization levels are characterized as follows:

Level 1. The choice of an $m \in M$action method (technique) from the set M of possible methods according to algorithm A.

$$\mathrm{A}: m \in M.$$

The main subsystems operating at this level are the measurement subsystem (P_1) and the coordination subsystem (P_5).

Level 2. Adaptation and modification of methods for solving problems under conditions of informational competition. An effective algorithm A for choosing a method of action is formed in the result of learning in actual conditions and the narrowing of the set of uncertainty H.

$$\mathrm{H} \to 0, \mathrm{A} = F\{G, K\}.$$

The main subsystem functioning at this level is the information exchange subsystem (P6).

Level 3. The self-organization and selection of a strategic model is carried out on the basis of justification and assignment of the current operators G of outputs K, assessment of the quality of the action method, corresponding to the main goal S(t).

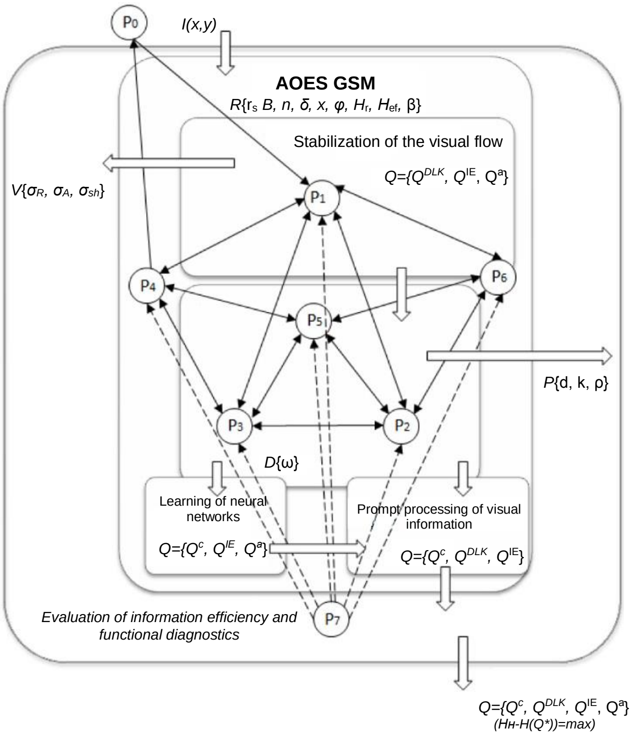

Fig. 2 Reorganization scheme and mapping of the multilevel AOES GSM on the conceptual-logical model

Outputs operator G defines a rule for displaying a set of X elements at the input to the set Y of output results for a $m \in M$given method of action selected from the set M under conditions of uncertainty H.

$$\mathrm{G}: \mathrm{X} \times \mathrm{M} \times \mathrm{H} \to \mathrm{Y}.$$

The operator K evaluating the quality of the method of action determines the rule for displaying the set Y of output results for a $m \in M$given method of action selected from the set M into the set of quantities R associated with the characteristics of the system operation quality

$$\mathrm{K}: \mathrm{M} \times \mathrm{Y} \to R.$$

The main subsystems operating at this level are the observation subsystem (P_2) and the identification subsystem (P_3).

Level 4. Administrative management, decision making based on the received analytical information. The main subsystem functioning at this level is the decision making subsystem (P_4).

At the same time, the required degree of security and safety of information arrays is supported by the information protection subsystem (P_7) continuously at all levels. Information security includes ensuring the reliability (noise immunity and noise proof features), confidentiality (secrecy, accessibility and imitation resistance), safeguarding (integrity, availability) of privileged visual information. Thus, information security consists in the ability to prevent accidental or deliberate distortion or destruction, disclosure or modification of information arrays in the information base [10].

IV. ENSURING INFORMATION EFFICIENCY AND SECURITY OF AOES GSM IN THE CONDITIONS OF INFORMATION COMPETITION

One of the main requirements for developing the effective AOES GSM is to ensure the quality of processing of meaningful visual information received at the system input in the form of an information flow.

When developing an effective AOES GSM, the most important task is to determine the quality indicators of information security (Fig. 3).

The quality of information processing can be characterized by a combination of properties that determine the degree of its compliance with the goals of processing. In the general case, one can distinguish internal quality indicators that characterize the system content richness and external quality indicators that determine the security of the system [11, 12,13].

Internal quality indicators are responsible for such properties of information processing as materiality - a property of information that allows you to maintain value over time and includes indicators of completeness, ensuring rationality of management, and relevance, responsible for compliance with the dynamic state of objects, as well as cumulativity - a property that allows reflecting reality in a small informational array and includes selectivity indicators providing the qualification choice of a limited number of information units from a large-volume informational array, and homoformism, which allow aggregating large informational arrays into a small number of informational units [14, 15].

External quality indicators provide confidentiality properties for the reliability and safeguarding of information. The confidentiality property determines the status of the information external availability and is characterized by accessibility indicators (determining the degree of differentiation in the use of information arrays), secrecy (consisting in the ability to withstand the disclosure of the information meaning), imitation resistance (determining the degree of information protection from implementation and consisting in the ability to prevent disinformation from entering the system).

The reliability property characterizes the degree of correspondence of real information units to their true value and is determined by the parameters of noise immunity and noise proof features. The safeguarding feature is the possibility of targeted use of visual information arrays and the ability to prevent violation of the integrity of information arrays during the system operation.

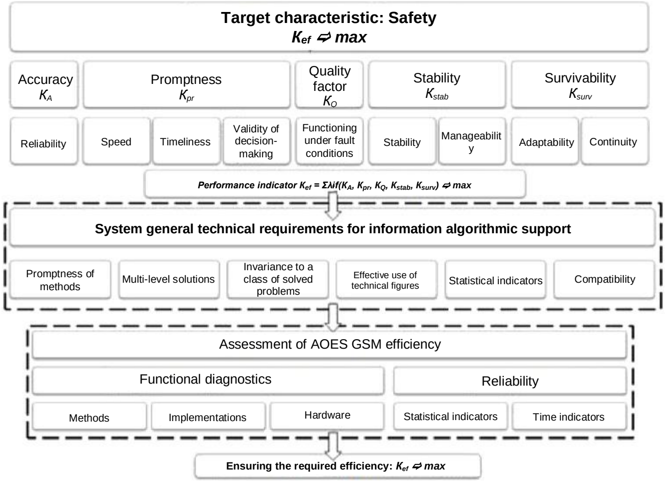

Figure 3. Ensuring efficiency of AOES GSM in the conditions of information competition

The process of processing visual information covers a wide range of methods with various applications. A certain set of methods is distinguished among the variety of the same in order to develop algorithms for solving specific tasks.

In the general case, the technological process of processing the visual information flow is a series of sequential actions aimed at analyzing information and bringing it to the desired form at the system output. All the steps for processing visual information, as a rule, are a sequential removal of non-informative components from the image and the selection of informative ones to solve the tasks. The following three main technological operations can be distinguished in the technological process of processing the input information flow. *The first one* is reception, including the processes of formation and registration of images, as well as their preliminary compression and restoration. *The second one* is the interpretation resulting in intellectual processing, generalization of the received data, control and decision making.*The third one* is the communication operation responsible for receiving and transmitting information flow. The main operations, in turn, include various subprocesses that allow to form, register, compress and restore images, summarize information obtained as a result of intellectual processing and make management decisions based on the same, as well as transmit and save information.

In order to ensure security, partially processed visual information containing certain data necessary to ensure further restoration of full significance is transmitted to the communication operation instead of the general array of visual data. For example, in case of using neural network methods of decoding visual information, learning samples are generated, and the weights of the neural network obtained in the process of learning are transmitted for further work through the information channel instead of arrays of learning images.

The main characteristics affecting the efficiency and safety of AOES GSM are indicators of information accuracy K_A, promptness K_{pr}, Q-factor K_Q, stability K_{stab}, survivability of K_{surv}, each of them corresponding to a certain importance indicators $0 \leq \lambda_i \leq 1 \sum \lambda_i = 1$, , i = 1, ..., 5. The main qualities of these characteristics are the maximum use of the potential capabilities of AOES GSM. Information security of AOES GSM is defined as a function of private performance indicators

$$K_{ef}=\Sigma\lambda i\ f(K_A, K_{pr}, K_Q, K_{stab}, K_{surv}) \Rightarrow \max.$$

V. CONCLUSIONS

The main approaches to providing secure processing of visual information under conditions of informational competition in the automated optoelectronic ground-space monitoring system are presented.

The considered proposals for ensuring secure processing of information in AOES GSM are of theoretical and applied importance in solving the problems of developing effective automated optoelectronic systems of special (intersectoral, etc.) designation, providing processing of multi-aspect visual information. They can significantly increase the efficiency of using existing methods and tools for detection, localization and classification of images and, as a result, improve the quality of visual information recognition, ensure the confidentiality of information processing, and also increase the safeguarding and reliability of situation assessment under conditions of intense information competition and continuously changing environment.

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