MODELING OF BEHAVIOR AND INTELLIGENCE


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Abstract—Programming of an adaptive information security system (ISS) is reduced to describing of information fields of neural networks (NN) in the form of batch neural-network programs. A similar description of data-field component makes it possible to study processes of operation and adaptation of neural-network ISS in the composition of computer-aided systems by modeling the interaction of operating data with the information field of NN.

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1. INTRODUCTION

We can see the parallel between the evolution of types of biosystems and complex computer-aided systems (CAS) [1]. Biosystems develop due to perfect security of information processes; further development of complex technical systems is possible when a level of CAS adequate to the growth of complexity of information technologies is ensured. A promising technique for developing information security systems (ISS) is the use of the analogy of security mechanisms for information processes in biosystems and complex technical systems.

Evolution of CAS is in the trend of creating intelligence systems in which there are processes of investigation, adaptation, development, and selection [2]. These processes are realized with the use of the analogy with biosystems [3] that have high functional stability and protection when threats are changing.

In the model of hierarchical adaptive defence are used defence mechanisms of immune and nervous systems of biological organisms. At the bottom of the defence hierarchy are solved problems of classification and threats clustering; at the top of defence hierarchy, accumulation of experience of neutralization of the threats by means of defence mechanisms. Levels of defence hierarchy correspond to information fields that make the character of the information security system evolutionary, namely: information fields of ISS can be transferred to sequential versions of the system (inheritance), corrected in changing operation conditions, set of threats, and list of applied defence mechanisms (adaptation and development), perform optimization of both the structure of ISS and information fields according to the objective function (selection) [4].

A formal model of processes in information fields of neural-network ISS in main operation modes is necessary for adequate representation and development of methods for projecting and verification of neural-network ISS described by batch neural-network programs (BNP). As is demonstrated,
BNP is an oriented graph and the model of BNP is meant for describing parallel distributed processes in information fields of neural-network ISS. It was proved that a BNP-model is a parallel asynchronous model with decentralized control [5].

We shall show that programming of neural-network information security systems is reduced to describing the structure of information fields by means of BNP. The description of the structure of information fields makes it possible to detail and investigate processes in neural networks of hierarchical levels of adaptive security by modeling the interaction between operative data and distributed redundant information fields of neural networks (NN).

2. MEANS FOR DESCRIBING NEURAL-NETWORK INFORMATION SECURITY SYSTEMS

Information immunity of biosystems is stipulated by a distributed spatial programming technique and is not in describing behavior algorithms in the form of predefined sequence of actions but in assigning the structure of information fields. At the molecular level, programming of biosystems is expresses in spatial organization of DNA; at the level of the nervous system, in distributed information fields of neural networks. In both cases, to ensure information immunity, mechanisms of redundancy, distributed character of representation and parallel data processing, adaptivity, possibility to transfer knowledge in the form of life experience are used.

To represent processes in the form of a structure of interrelated operational nodes, we can apply the language of graphical description of objects that uses the control method for distributed calculations by data flow. Operational nodes correspond to command batches (CB) defining both the realized computer operation and system of communications with operational nodes, i.e., receivers of results. By using the mechanism of data availability, we reject forced assignment of the order of fulfillment of computer operations, which makes it possible to realize parallelism of the problem in question [6].

We shall define the notions that will be used for describing processes of operation and adaptation of neural-network ISS.

A batch neural-network program is a functionally completed union of interrelated command batches.

A command batch is a structural component of BNP made by a union of specialized fields and defining both the operation of neural-network basic and numbers of command batches-receivers of results.

A data packet (DP) is a delivery tool (container) of data values from one CB (source) to another CB (receiver of results).

2.1. Representation of Elements of the Neural-Network Basis

A neural-network basis involves functions and components that can be considered as a graphical language for describing NN [7]. Each of the components of the neural-network basis may be put in correspondence with CB from which we can form functionally complete sets of CB and further use them as elementary program and structural unities [8] for representing hierarchies of levels of a neural-network ISS in the form of structured information fields as BNP.

Interneuron link (synapse) fulfills the operation of weighting of the input signal \( X_i \), \( i = 1, 2, \ldots, n \) (Fig. 1) by multiplying its value by the value of the link weight \( W_i \). Synapse corresponds to CB containing the communication field of the receiver of result \( D_i \), filed of functional parameters \( W_i \) (with gated code \( C \), i.e., const), field of the input port \( X_i \), and field of data availability \( R_i \) (both with gated code \( N \), i.e., not).

If to transfer the function of weighting the signal to the replicator, then we obtain an output star, whose CB contains fields of link weights \( \alpha_1, \ldots, \alpha_m \), and fields of receivers of result \( D_1, \ldots, D_m \).