NEURON AS SELFLEARNING SYSTEM OF PATTERN RECOGNITION. ADAPTIVE CONTROL IN NERVOUS SYSTEM

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There are three approaches for investigation of neuron. 1st of them is "biological" one; it consists of careful analysis of traceable details of neurons and its environment. This is very relevant source of knowledge but anytime there is a possibility to lose some essential for understanding features, which are hidden by Nature in different forms as result of long-term evolutionary optimization. 2nd approach is "pragmatic" one; it leads to simulations of final application results but does not more transparent the principle of operation of brain (so chess computer has not principle of operation of brain). 3rd approach is "logical-rational" one; it consists of putting forward a well-founded hypothesis about concept of biologic life and clearly recognizing of relevant problems that stand before organism. All this leads us to the clear understanding of composition and structure of organism and its nervous system. Then we can perform the aimed experiments to find biological organs and processes that have implemented these functions. In this paper we present logically based conceptual model [1] of nervous system and its element – neuron that follow from application of "logical" approach to problem of understanding of brain principle of operation.

We go from the assumption that each living organism tries to keep its identity (the survival) in conditions of aggressive environment by means of rational control, which solves such intelligent tasks as recognition, learning, predicting and some others. This assumption forces us to do following conclusion: nervous system of each organism simply must solve two complex problems a) *learning* - active finding of knowledge about properties of the world (environment, organism, etc.) and its accumulation and b) *survival* by means of control on base of accumulated knowledge. Satisfaction of these two goal functions at whole gives to the organism the autonomous adaptive control.

For solving of the problem (a) the nervous system has to work according the algorithm is well known from epistemology. This algorithm forcedly follows from essence of the problem of finding and acquisition of knowledge in a priori unknown environment. Philosophers have found and described this algorithm long ago. The algorithm consists of following steps: 1) do the analysis of having knowledge, generalize it, find regularities (the knowledge) and do the prediction based on the knowledge (may be the prediction will have a distribution of probability of possible results); 2) do the test of the prediction validity. For it do one or a few corresponding actions–experiments in framework of the distribution of probability; 3) add new experimental data to previous data; 4) go to step (1).

For solving of the problem (b) the nervous system has to do decision making not only with goal function of knowledge acquisition but also with goal function the survival too. We mean the survival as keeping of homeostasis and development of the organism and searching of new facilities. For use of knowledge for survival the nervous system must have tool for qualitative estimation of past, present and future conditions and situations. We think that each nervous system has the tool – it is the emotions system. We guess that operative information and some part of knowledge in nervous system are presented in discrete form. It follows from discrete form of nervous pulses, finite number of sensors, neurons and nerve-endings. It gives to us a basis to speak about the presenting of the information in form of discrete signals and the presenting of the knowledge in form of discrete objects – the *patterns*. The patterns reflect objects, processes, scenes and situations that are important for the given nervous system.

Were based on this assumption, we have made the conclusion that the nervous system working on these two goal functions must be able to solving of following tasks: i) automatic classification for forming of set of possible categories, ii) pattern recognition, iii) automatic classification of controlled causal-effect situations. These are special kind of patterns – knowledge, which can be used for control, iv) the forming and using of qualitative estimations (emotional appraisals) of patterns, v) decision making with taking into consideration of two goal functions – knowledge acquisition and survival.

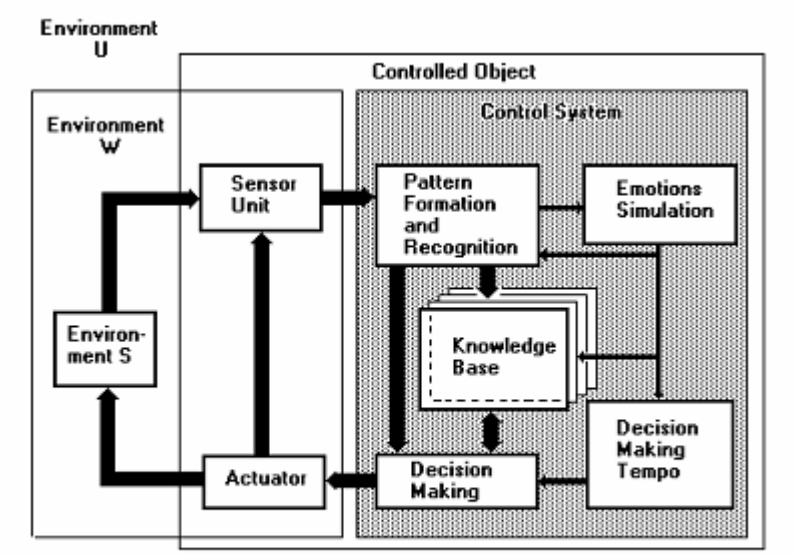

Fig 1.

The logic sequence of the decision of the listed tasks dictates the quite certain structure of subsystems of nervous system [1] (fig. 1). It is subsystems intended for the solving of tasks (i) - (v), and also memory units are necessary for them. In the paper we do not make any assumptions about a way of realization of the described logically necessary subsystems found by Nature during evolution process. These subsystems may be local or distributed, they can be implemented in work of neurons or chemical mediators, genes or in others manners.

The analysis of the tasks of specified subsystems shows that the most of them can be formally reduced to functions of self-learned recognition systems (automatic classification plus pattern recognition). Although the input data for them have various sense but the data have identical form of "binary" nervous pulses. As it is known that neuron is the basic constructive element of nervous system then from here follows that biological neuron is elementary self-learning recognition system. A first task of neuron is the detection of a not casual spatial-temporary configuration of input signals – a pattern. The second task of neuron is the recognition of the pattern among all other situations on its inputs and the signaling about the pattern recognition fact by means of the output signal. Hence, in neuron's life we have to see two consecutive phases - phase of training and subsequent working phase when neuron plays a part of the learned recognition system.

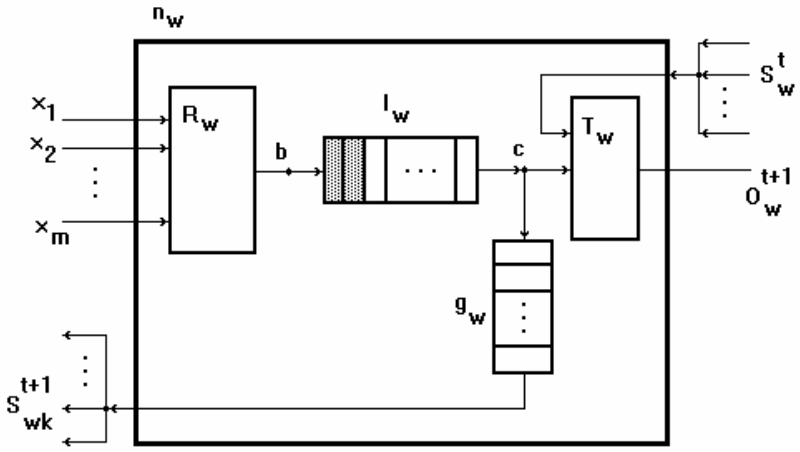

Fig 2.

We developed a model of neuron [1] (fig. 2), which corresponds to the states above. The neuron model represents elementary self-learning recognition system. The rule of pattern formation in the neuron uses a structural criterion for the account of a spatial configuration of input signals (unit *R*) and statistical criterion for the account of the configuration repeatability (units *l* and *g*). We described [1] how all listed tasks can be solved by means of such neuron model and how models of nervous system can be created on base of the self-learning neuron.

References

1. А. А. Жданов. Бионический метод автономного адаптивного управления // От моделей поведения к искусственному интеллекту. Серия "Науки об искусственном" (под ред. Редько В.Г.). М.: УРСС, 2006. С.343-385.