Five Strategies of the Self-Tutoring of a Neural Networks by E. Sokolov

George Losik,
UIIP National Academy of Sciences, Minsk, losik@newman.bas-net.by

Abstract: The bionic models of neural networks are of interest. A bionic model that suggested by Prof. E. Sokolov consisting of detectors and control neurons. In his model the self-tutoring is designed, the environment and a purpose of neural network's behaviour are considered. In this article five various strategies as five rules of tutor a motor neural network by E. Sokolov are considered responding to tutor of a sensory neural network..

Keywords: bionic neural network, strategy of tutoring.

I. INTRODUCTION

It is generaly accepted to underline three aspects in developing neural networks which virtually functions: neural network structure, learning stimuli sample, algorithm for tutoring neural networks or self-tutoring. [1,2]. Especially the article devotes algorithm for tutoring neural networks development. This aspect is rightful considered separately from the first and second ones. The third aspect presupposes the presence of "teacher" who organises, brings external objects or scenes at the input of neural networks.

Usually the mode of the self-tutoring appears to be impossible in current neural networks. As there is no external "manipulative part" in neural networks which is able to influence on external objects, move the neural network and organise the learning stimuli sample independently on the teacher. The creation of neural networks starts to be worked out which have not only a sensory teaching part but also a motor teaching part.

According to above–mentioned, *bionic* projects of neural networks are of interest. A bionic model of the pointed type is a model consisting of detectors and control neurons suggested by Prof. E. Sokolov [3] (see Fig. 1).

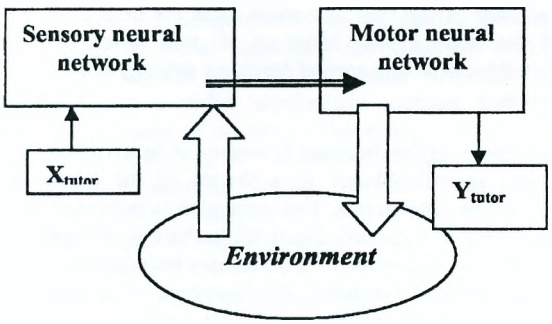

Fig 1. The conceptual reflex arc

In this model the self-tutoring is designed, the environment and a purpose of neural network's behaviour are considered.

The **aim** of this work is to concede the five various strategies as five rules of tutor a motor neural network by E. Sokolov responding to tutor of a sensory neural network.

II. BIONIC STRUCTURE OF NEURONETWORK

Numerous works on the creation of the neural networks of a non-bionic type [2,1] are restricted by modelling sensory processes. We usually put a task to teach the objects recognition and their difference from each other to the non-bionic type neural networks [4]. The teacher instead of the environment teaches neural networking reactions through the medium of learning stimuli sample $\mathbf{X}_{tutor}$ of every objects and an order into its input with regard to $\mathbf{Y}_{tutor}$ reaction that the latest layer of the neural network must learn to response to. A well-known method of ***back propagation algorithm*** represents a strategy of teaching the scales of all layers of the neuron network [2].

However the neural networks that has been trained to recognise the sensory objects moreover, in accordance with Sokolov's model, can be supplemented by the ***motor*** neural network that has been already trained to make motor (mechanic) movements in the environment (see Fig. 2).

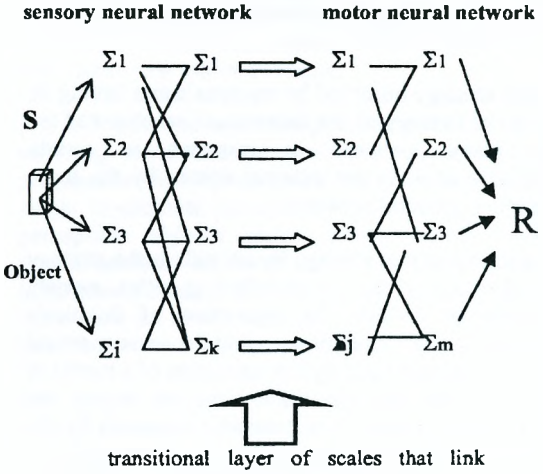

Fig. 2. The neural networks for sensory objects in Sokolov's mode was supplemented by the motor neural network that has been already trained to make motor movements in the environment

By Sokolov's bionic neural network - motor movements synthesize with layers of control neurons, motor neurones and moving elements. Then, the sensory and motor neural network can be put into the certain, physical environment whose actions and condition the first one is able to recognise and the second one can change by influences (see figure 1). A conceptual ***reflex arc*** by E. Sokolov is a version of such scheme:

III. BIONIC TUTORING STRATEGIES

What does the idea of the neural network's self-tutoring conclude in if the sensory and motor neural networks have been already trained? We have the following ground for this. It consists in teaching a *transitional* layer of scales that link outputs of the sensory neural network with inputs of the motor neural network [4]. We'll be able to observe precisely the challenging process of the formation the "adaptable skills" of the neural network in future. They are following: to exist in the environment; to remain undamaged "satisfied" and do the useful work for a constructor. Having rendered such strategies E. Sokolov disting among them only five strategies.

In accordance with Sokolov's terminology these are: ***firstly*** the teaching strategy of the decrease of a reaction of the motor neural network responding to certain biologically unimportant, external scenes by the input of the sensory neural network; ***secondly*** the teaching strategy of the increase of a reaction of the motor neural network responding to certain non biologically – "important", external scenes by the input of the sensory neural network; ***thirdly*** the teaching strategy of the increase and fastening of reactions of the motor neural network responding to the simultaneous presence of a certain external scene and the justified reinforcement owing to the fact that the scene entails the biological advantage (food, pleasure, enjoyment) or biological disadvantage (the threat of damage, discomfort).

The ***first strategy*** observed by mammals and having its sense is the strategy of the decrease of reactions of the motor neural network in response to certain biologically unimportant external scenes by the input of the sensory neural network.

The analogue of this strategy by animals is the strategy of the decrease of the position-finding reflex, namely the reflex of novelty. In opposition of Sokolov's opinion we'll make more precise that the sensory neural network is characterized by the formation of a model of frequent objects. At the same time the object has certain characteristics. It is precisely measured by the selectively sensory neural network responding by reactions. A model of frequent "object" or scene is formed by the sensory neural network in accordance with our concept. An object is a complex of stimuli which distinguish not only by certain *metrological* but by biological characteristics – subjectively useful and harmful for living creatures. That's why in the first case the metrological accuracy can be possible by the creation of the frequent stimulus model considered by the sensory neural network.

The second case shows that in addition to layers of neurons, neurones layers appear *distorting* the nature of stimulus, remaining exact or doing rough the measures of the subject's parameters depending on how well the object and a parameter are biologically informative. In the first case the sensory neural network reconstitutes regularities of psychological feelings (differential threshold, sensitization, adaptation). In addition to these regularities the sensory neural network still reconstitutes regularities of the psychological perception (constancy, consciousness). In contradistinction to modern neural network mammals recognise biologically important objects against background of various other unimportant objects simultaneously appeared at the input of an analyser.

How can we differ the background from the object? Perhaps animals perceive well the *background scenes* from a plenty of surrounding subjects. The strategy of the decrease responding to motor reactions is the reason for the transfer of a perceptible object into a background category. For example it is a case though we take the object into our consideration it has no great importance for us. Every day a person wears his own clothes perceiving it visually and tactually (wrist-watch, shoes, gloves) represent as objects of the visual perception. Thanks to the decrease of the novelty of a position-finding reaction, they do not engender our motor reactions though they are recognized perceptibly and make up the perception background. At the same time unless the stimulus and the object change their customary characteristics, it produces the appearance of a position-finding reflex. At the beginning the motor system evaluates the novelty of a background scene metrologically and then the motor system reacts to an output vector of detectors' layer of the sensory system causing various acts.

We suppose that the decrease by ***I. P. Pavlov*** of a conditioned reflex and the decrease of reactions to a background object are different phenomena. The conditioned reflex is the habitual combination of 2 signals or objects. In our case a single customary object generally can weaken a motor reaction and turn into a background one. As for the conditioned reflex it provides for the stimulus, sustenance (food); the decrease of the first one starts after the disappearance of the second one. Most of all this reflex can be coincided with the second teaching strategy considered below.

A strategy of the decrease of a reaction to a background object is resemblance to a theory of the automatic control ***in cybernetics***. The correction is not made on a trajectory of a rocket's flight while there is no signal of the non co-ordination of a customary trajectory existing at the present moment. The decrease of a position-finding reaction influences not only a separate object of the perception but also a "scene" of objects: their usual

order in space or on a "trajectory of the object's examination; their habitual sequence their interchange in time.

By G. Gibson [5] mammals are characterised by the eagerness of being in the refuge. It helps to protect the organism from enemies and moreover to preserve the habitual environment for its perception system. According to M. Kremen's [6] concept the repeated perception of the same temporary range of scenes forms an image "flight" by the person. Here position-finding reactions gradually go out which are replaced by the background perception of customary scenes. The automatism both by the person and animals' walking links with the automatism of stereotyped movements of motor organs as well as the automatism and the perception of these movements. A stereotype of the interchange of visual scenes by walking gradually leads to going out the position-finding reflex against the novelty because of the transfer of a chain's recurring sequence of perception subjects, feelings, that make up a step' cycle, to the level of the background perception.

The ***second strategy*** by E. Sokolov is a strategy of the increase of reactions of the motor neural network in response to certain "interesting" objects and phenomena for an organism at the input of the sensory neural network. It differs from the below-considered third strategy in the following: it does not demand a modulating input signal by commanding neurons of the motor neural network and manage without a supporting neuron of a central signal. The second strategy conditionally can be coincided with the reflex by animals characterizing by the involuntary ***imitation***. As it is known, animals of the same kind give and gain experiences from one to another imitating the behaviour of each other. The motor acts with subjects, communicative movements of the same individual (mimicry, pose, pantomime, speech) are the perception subject of another individual. These are subjects of a peculiar characteristic. Besides the sensory neural network, an individual of the same kind has a "synthesizer" of a perceptible phenomenon. That's why if it is interesting and useful for an individual after the formation of a object's sensory image, an individual can be trained for the imitation and formation of a motor image of the same object.

The behaviour of mammals conditionally can be divided into the behaviour of uncommunicative and communicative sense. Especially the second teaching strategy is observed by a child in spoken language. At the beginning a child involuntary imitates sounds, syllables, phrases of an adult. The research of child's speech has shown that at first auditory images of vowel and consonant sounds, syllables, intonation models of question, narration, surprise start to be formed by a child in the sensory neural network.

According to auditory standards the child appraises the success of his endeavours to repeat a speech sound motoraly. Therefore those reactions are fixed which are evaluated successfully by the sensory neural network. The balance of an output layer of the sensory neural network and an input layer of the motor neural network are simultaneously determined establishing the accordance of reactions in sensory and motor systems . The ***third strategy*** having the rather high biotical importance is a strategy of the increase and reinforcement of reactions of the motor neural network in response to a certain external scene together with the justified encouragement. It appears from central brain parts as the input scene has entailed neither the use nor danger for an organism. Therefore a perceived subject becomes a perception object as well as food, clothes, labour implements, means of conveyance and communication. Moreover it can turn into the threat for life and a reason for pain and discomfort. What was the reason for such appearance by the input of this subject? An organism controls the test of a hypothesis: "what has my current motor act caused this reason"?

It changes a vector of motor acts of its motor neural network. Besides it gives a great importance to whether the pain or pleasure has disappeared by the input. In this case there are 4 possibilities.

The first one: the input pleasure is a consequence of its own motor act. In this case there is the justified encouragement for teaching. An excitement vector of sensory is associated with a necessary vector of motor. *The second* possibility: the input displeasure is a consequence of its own motor act. The organism quickly finds contra-actions against the displeasure. The justified support (encouragement) fixes the link between a contra-action and the elimination of a negative sensory scene. *The third* possibility: the input pleasure is a consequence of external circumstances and reasons. The justified support (encouragement) is not delivered. *The fourth* possibility: the input pleasure does not disappear because of a next motor attempt. The justified support is not delivered while the quest for a motor contra-action goes on. The organism finds and makes new motor attempts.

We will describe a ***fourth possible*** teaching strategy differing from above-mentioned strategies. In our previous works [7] we underline the necessity of the single co-ordinate perception influence for studying a perceptible object's shape. Sometimes the sensory system operates the motor system that allows the motor to influence a perceptible object in order to get to know better both the object itself and a vector of extents of its freedom.

The **aim** of a strategy of management is to arouse selectively one of control neurons one by one of the first layer of the motor neural network but not a group of neurons simultaneously. The sensor system must know the object's reaction in response to one or another elementary influence. Correction neurons are formed by the sensory neural network which fix the accordance of a vector of the motor computer influence on the object and a vector of shear in the sensory neural

network. Such strategy demands the quickness, the single co-ordination of a motor act, the next short-termed blockade of the whole motor system not to obscure the sensory system.

IV. CONCLUSION

We can make a conclusion that the teaching of the behaviour namely the motor system among mammals is not restricted by one strategy of back-propagation algorithm to the non-bionic type neural networks [1,8,9].

In this work we distinguish five bionic strategies or rules that used by mammals. The strategy of back-propagation algorithm is mostly resemblance to the third strategy of teaching the behaviour: to get pleasure and avoid displeasure.

The first strategy of the behaviour teaching among living creatures is conditionally connected with the teaching of reactions to the new environment to be exacted, that assists the organism in transferring a lot of gained skills, knowledge to the rank of the background. Therefore the reduction of motor reactions goes on in response to unattractive sensory images and scenes.

The second strategy is associated with the ability of an animal to imitate some useful phenomena, behaviour and communicative acts, having perceived from other individuals of the same kind. This category of perceptible "objects" has another biological sense. So an animal finds it expedient to train for their imitation, namely, the creation of their physical models. Here there is the increase of typical motor reactions responding to "interesting" sensory objects.

The third strategy of the sensory-motor behaviour teaching relates to acquiring skills aimed at getting pleasure and avoiding displeasure. This category of perceptible subjects is most actual and vitally important for the animal world. The organism reacts to their appearance by the input with great interest. Having reacted emotionally, the organism is trained for responding to them by a motor reaction that becomes obligatory later on.

We underline **the fourth strategy** of teaching the motor system which undertakes to a perceptive function realised by the sensory system. The sensory neural network teaches the motor neural network to give perception influences on a perceptible object in order to get to know a object and its shape deeper as well as extents of its freedom. All semantic links of the sensor system are fixed to the motor system which provide for fast, strictly co-ordinate motor influences of an animal on a object.

According to Sokolov's theory **the fifth strategy** can be picked out as an independent strategy of the visual system of watching an "aim". It is a rather important function of the moving of a neck and body's muscles. It is a skill to watch and "keep" an image of a necessary perceptible object on the retina in the zone of the best perception. The analogy of this skill is an arm skill that provides the best tactual touch of the skin of palm and fingers to a object. It is also analogous to a skill of the person's visual system to watch the movement of hands of own arms. Here the sensory-motor system is trained to fulfil a function of a three co-ordinate regulator.

REFERENCES

[1] V. Golovko. Neural Intelligence: Theory and application. Book 1. Brest. 1999.

[2] S. Haykin. Neural Networks: A comprehensive Foundation. New York: A comprehensive Foundation. 2nd Edition, Prentice Hall, New York: Macmillan College Publishing Company.- 1999.

[3] E. Sokolov. The Perception and Reflex: New vision. – Moscow, 2003. - 288 p.

[4] T. Poggio. Toward an Artificial Eye. *Journal IEEE "Spectrum"*, May, 1996. - P. 20 - 74.

[5] G. Gibson. Ecology concept of Eye's Vision. - Moscow, 1998. 340 p.

[6] M. Kremen. Psychological Structure of Looking // *Questions of Psychology*. 1997. - № 6. - P 70 - 78.

[7] G. Losik. Neuron model with main and modified input // Proceedings of the II-th International Conference of Neuron and networks Sciences. Minsk, 2001. - C. 220-231.

[8] Fahle, M. and T. Poggio, Perceptual Learning, MIT Press, Cambridge, MA, 2002.

[9] V.A. Golovko, A.D. Dunets, P.V. Seleznev. The license plate recognition by using neural networks. 8th International Conference on Pattern Recognition and Information Processing (PRIP'05), that will be held in May 18-20, 2005, in Minsk, Belarus, p. 465-467.