# Do Intellectual Systems Need Emotions?

Maksim Davydov,
Anatoly Osipov
*Belarusian State University*
*of Informatics and Radioelectronics*
Minsk, Belarus
davydov-mv@bsuir.by, osipov@bsuir.by

Sergei Kilin
*B.I.Stepanov Institute of Physics*
*National Academy*
*of Sciences of Belarus*
Minsk, Belarus
sergei_kilin@yahoo.com

Vladimir Kulchitsky
*Institute of Physiology*
*National Academy*
*of Sciences of Belarus*
Minsk, Belarus
vladi@fizio.bas-net.by

***Abstract*—One of the unresolved issues in the problem of artificial intelligence is the question of the desirability of introducing elements of motivation and emotions into artificial neural networks. The attitude to this issue is still controversial. The coding system in the interfaces is based on the binary system of the "on-off" type. In the case that an emotional component is included into the artificial intelligence system, it is advisable to introduce, along with binary coding system, a positive or negative attitude to the decision which is being made by implementing a feedback system. Thus, the "on" or "off" due to the feedback can, at a certain level of "noise" or emotional disturbances, decline or turn into appropriate opposite. This article presents an attempt to critically understand the existing problem of an effective result of artificial intelligence in the presence of positive or negative emotional component of varying intensity and duration. It is important that all events associated with artificial intelligence functioning should be considered not as static ones, but as events developing simultaneously in time and space.**

***Keywords*—intellectual systems, feedback, emotions, natural neural networks**

## I. Introduction

Artificial intelligence got its name due to the fact that researchers have been trying to create a system that fragmentarily uses the architecture of natural intelligence and, this way, approximates in its capabilities the natural intelligence [1]. Since intelligence is often associated with human abilities in the field of creativity, when creating such system it is necessary to take into account as many of the constituent elements, presenting attributes of the creative realities of natural intelligence, as possible. One of these elements is emotional component of the natural intelligence [2-7]. Experts discuss the feasibility of the component, but in reality it is not widely used in modern models– of the artificial intelligence. Let us give some examples from everyday life to confirm this idea. The role of the emotional state of poets, for example, Pushkin and Virgil, when writing good verses in the morning, after sleeping, is well known. The examples above confirm the importance of the emotional component in the formation of the final result in the activities of the neural networks of the brain and the whole organism. In the previously published article by the authors of this paper, this component was actually schematically indicated only [8]. In this report, we will try to understand the existing problem in more detail.

## II. "To be or not to be", do intellectual systems need emotions?

Marvin Minsky believes that emotional cycles lead to long fixation, thus reproducing a contrasting emotional state (joy-grief) [1]. From this point of view, the addition of the emotional component to the system of artificial intelligence will inevitably be accompanied by the formation of an external reaction of the intellectual system, which indicates the relation of the system to the decision made [9-13]. That is, in fact, it is possible to determine the success or failure of the task performed, by considering the external behavior of the artificial intelligence system.

Experts in the field of artificial intelligence, who create computer architecture to reproduce the human brain in the form of chips and interfaces, build the boards which consist of 16 million neurons as, for instance, the board made by the experts from IBM. For comparison, the total number of neurons in the human brain amounts from 80 to 100 billion. Thus, additional development of technologies is required to ensure more realistic consistency between the artificial intelligence and the natural one. These examples demonstrate the importance of the emotional component in the functioning of both natural and artificial neural networks [14-16].

Further. If, in the process of artificial intelligence creation the option of complete analogy of the artificial intelligence with the natural intelligence has been chosen, then we arrive at well-known fact that depression, depressed state of a person is often accompanied by a complete lack of efficiency and, in fact, by the blockade of functioning of neural networks responsible for the efficiency of performing complex tasks. While in case of model experiments such effects are interesting and valid for the analysis of final and sometimes fatal outcomes, the introduction of the emotional component into complex systems of artificial intelligence that are responsible for (critical processes) vehicle movement, rocket launch, piloting airplanes, etc. can lead to fatal results. For better understanding the essence of the problem, let us turn to the structure of the functional system by Pyotr K. Anokhin.

We note that the multi-element feedback scheme by Pyotr K. Anokhin [17-20] has an emotional component. The presence of feedback allows the neural networks of the brain to correct the signals coming from the brain to the executive organs in order to improve the action performed. In case of any deviation of the feedback signals from the pattern of command signals that initiate the execution of the action, adaptive changes occur in neural networks that control the effectiveness of the action performed. The result of these changes is the formation of a new pattern of command signals that provide more accurate implementation of the intended action. When the pattern of the conceived action and the pattern of the performed one are fully coincide, the functional system stops functioning as the planned result has been achieved.

Such coincidence of the conceived and performed actions is accompanied by the formation of positive emotions. In natural neural networks, this principle of operation is the basis for effective achievement of the result, when positive solution of the task is achieved within a short time and with minimum power consumption. On the other hand, the occurrence of additional "noises" in the functional system, the source of which are negative emotions, reduces the efficiency of the neural network functioning, since part of the neurons of the network, and sometimes the entire network, are simultaneously involved in performing at least two or several tasks.

The introduction of the emotional component into the system of artificial intelligence will inevitably be accompanied by additional noise caused by the processing of the "emotional" component and the assessment (consideration) of its role in making the final decision. For the time being, there is no clear answer to this question because of the relatively small number of works on this subject. But a priori, it is assumed that additional noise in neural networks that control the execution of any action will introduce additional interference in achieving the "final adaptive result".

Figure 1 shows in schematic form a variant of the functioning of the neural networks of the brain stem, which ensure the maintenance of vital respiratory function. The figure shows highlighted chemoreceptor link, which was formed in the process of evolution of the neuroglial cells of the brain (Figure 1). Brain stem chemoreceptors do not respond to hypoxia, but to a miniature shift of hydrogen ions in the brain tissue. Such mechanism of self-regulation of brain functions primarily ensures control of the intensity of metabolic processes in the brain, during which, even with normal amount of oxygen in the brain, acidosis is often formed in the brain tissue due to disruption of the reverse chemoreceptor function, which maintains the optimal amount of hydrogen ions (pH), the content of $CO_2$ as well as $O_2$.

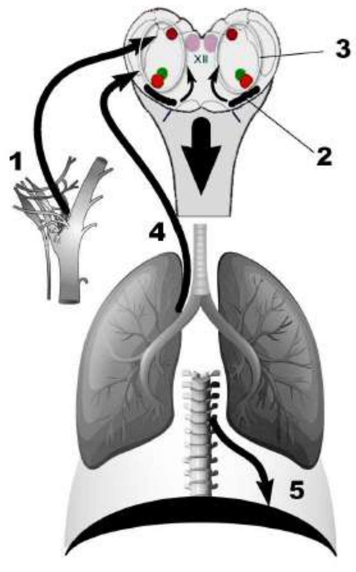


Figure 1. Regulation of lung ventilation (scheme). 1 - carotid body, 2 - medullary (central) chemoreceptors, 3 - respiratory center structures, 4 - vagal afferent nerve terminals, 5 - diaphragm. XII - the nucleus of the hypoglossal nerve. Arrows correspond to directions of signal flow (figure by Dmitry Tokalchik [25]).

Figure 2 demonstrates in vitro relationships in a network of neurons, which are the basis for the formation of reactions of neurons of one network when the functional state of neurons of another network changes. This figure shows more than 20 neuron-like elements with clear contours of processes. Dominated cells of 25-35 microns. There are single cells of small size of about 10 microns, which are also involved in the formation of a neural network.

As we know, the functional state of local neural networks has a direct impact on the pattern of total brain activity [4, 7, 18, 21]. This, in turn, determines the emotional state of a living organism [17]. Also, the emotional background is influenced by various chemicals: neurotransmitters, hormones and others. Neurotransmitters have a direct impact on the state of neural networks due to the fact that they transmit an electrochemical impulse from a nerve cell through the synaptic space between neurons. The release into the intercellular space of various mediators can inhibit or accelerate the work of individual neurons. And the work of a single neuron modulates the functional state of the neural network. Another feature of neurotransmitters is that they can have a selective effect. So there are neurons that have receptors for serotonin (serotonergic neurons), adrenaline (adrenergic neurons), dopamine (dopaminergic neurons) and others on the membrane. As a rule, one neuron is able to

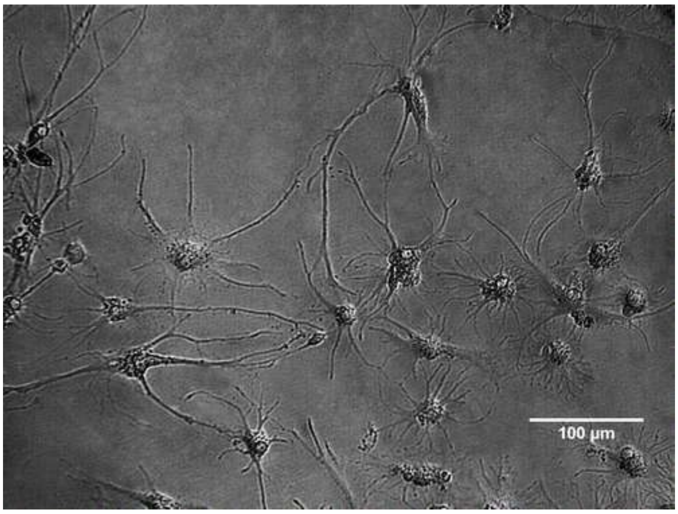


Figure 2. Formation of a neural network in an in vitro experiment.

perceive only one neurotransmitter. Thus, a certain type of neurotransmitter modulates the work of a specific part of the neural network. For example, serotonin is often called the “hormone of happiness,” and dopamine is an important part of the reward system. This is possible due to the fact that these neurotransmitters modulate the work of the neural networks of the brain, which are involved in the formation of a certain type of emotion: joy, satisfaction. It is not a secret for anybody that a person’s working capacity is connected with his emotional state. In an excellent mood, work is done faster, the efficiency of solving complex and non-standard tasks increases, and fatigue decreases. With a negative emotional background, in addition to a decrease in performance, problems may arise with social communication. In severe cases, pathological conditions develop: depression, symptoms of various mental illnesses. For example, the dysfunction of dopamine regulation of neural networks leads to disruptions in the functioning of the reward system. As a result, the person ceases to enjoy the work done, the task at hand, meeting with friends, tasty food and other pleasant events. In addition to the obvious changes in the emotional state of breakdown in dopamine regulation, the processes of learning and motivation are disturbed. It is natural that in this case a person has big problems.

Summarizing the above, a set of factors of different nature is involved in maintaining the normal operation of the neural network. These include the principles of organization and architecture of a neural network, the number of neurons and the methods of their synaptic contacting with each other (chemical, electrical, mixed). Also an important aspect in evaluating the neural network architecture is the structures (Figure 2) that are involved in the formation of synapses (axo-dendritic, axo-somatic, axo-axonal and dendro-dendritic synapses). This allows modulating the processing paths of information and the point of its entry into the neural network. It is also important to consider the environment in which the neural network elements are located. It is necessary to take into account not only the physicochemical parameters that ensure the vital activity and maintenance of the shape of the neural network and its components (Figure 1). It is also important to control and manage the balance of bioactive molecules, in particular, neurotransmitters. This will allow selectively activating and modulating the work of specific neurons and launch directed chemical cascades.

## III. Conclusion

Just few articles on the intellectual approach for adaptive control of a nonlinear dynamic system, including emotional training of the brain, are available [16]. The results demonstrated not only excellent improvement in the actions performed, but also smaller energy consumed by the dynamic system. There are more areas of application of artificial intelligence systems with an “emotional component”. The World Health Organization report for 2017 noted that almost 5% of the world’s population suffers from a deep depression, which is accompanied by a decrease in the quality of life. Psychotherapy does not provide any solution to this growing global public health problem. Technologies based on the artificial intelligence and evidence in interactive mobile applications can play a role in filling this gap. It is clear that such technologies will not replace health care professionals to more seriously address mental health problems. However, application technologies can act as an additional or intermediate support system [21-24].

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## НУЖНЫ ЛИ ИНТЕЛЛЕКТУАЛЬНЫМ СИСТЕМАМ ЭМОЦИИ?

Давыдов М. В., Осипов А. Н.,
Килин С. Я, Кульчицкий В. А.

Вопрос о необходимости введения элементов мотивации и эмоций в нейронные сети – одна из нерешенных проблем в области искусственного интеллекта. К данной проблеме до сих пор относятся противоречиво. Система кодирования в интерфейсах основана на двоичной системе типа включено/выключено. В случае, когда в интеллектуальную систему включается эмоциональный компонент, рекомендуется помимо двоичной системы кодирования вводить также положительное или отрицательное отношение к принимаемому решению путем реализации механизма обратной связи. Таким образом, под влиянием обратной связи состояние "включено"или "выключено"может при определенном уровне "шума"или под воздействием эмоциональных расстройств поменяться на противоположное. В данной статье предпринимается попытка критически осмыслить существующую проблему функционирования систем искусственного интеллекта при наличии положительного или отрицательного эмоциональных компонентов различной степени интенсивности и продолжительности. Важно понимать, что все события, связанные с функционированием систем искусственного интеллекта должны рассматриваться не как статические, а как развивающиеся одновременно в пространстве и времени.

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