УДК 371.315

Alexander Varnavsky

Ryazan State Radio Engineering University, Ryazan, Russia

EVALUATION THE PSYCHOLOGICAL STATE OF A LEARNER IN THE E-LEARNING SYSTEM*

ABSTRACT

The article considers the possibility of evaluating the psychophysiological state of a learner in the e-learning system. A logistic model was built, based on the regression analysis of the experimental data, allowing to evaluate the ability of the learner for effective learning before he enters the system. Galvanic skin response was proposed as a means to control the state of the learner upon learning. A network model was developed, describing the work of the e-learning system considering the psychophysiological state of the learner.

KEYWORDS

E-learning system; psychophysiological state; indicators of cognitive processes; logistic model; galvanic skin response; network model; initial state of the learner; current state of the learner.

Варнавский А.Н.

Рязанский государственный радиотехнический университет, Рязань, Россия

УЧЕТ ДИНАМИКИ ПСИХОФИЗИОЛОГИЧЕСКОГО СОСТОЯНИЯ ОБУЧАЮЩЕГОСЯ В СИСТЕМЕ E-LEANING

АННОТАЦИЯ

В статье рассматривается возможность учета динамики психофизиологического состояния обучающегося в системе в e-leaning. Оценить способность обучаемого к эффективной работе в системе предлагается с помощью логистической модели, разработанной на основе регрессионного анализа экспериментальных данных. Динамику и учет состояния обучаемого в процессе работы с системой предложено осуществлять на основе анализа его кожно-гальванической реакции. Разработана сетевая модель Петри, описывающая работу системы e-leaning с учетом психофизиологического состояния обучающегося.

КЛЮЧЕВЫЕ СЛОВА

Система электронного обучения; динамика психофизиологического состояния; показатели когнитивных процессов; логистическая модель; кожно-гальваническая реакция; сетевая модель; начальное состояние обучающегося; текущее состояние обучающегося.

Introduction

Nowadays, e-learning systems or distance learning has become very popular among part-time students or for independent works of full-time students. The users study the data proposed to them on HTML pages in those systems. The advantages of using those systems not only include the ability of the student to choose an optimal schedule, but also the possibility to personalize [1] and adapt the learning process, taking into account the individual properties of the learner, and his current training level [2]. An analysis of works dedicated to improving the efficiency of e-learning systems, has shown that they are mainly directed precisely at evaluating the initial or the current level of knowledge and skills of the students.

Courses in which the individual abilities, knowledge and skills of the student are evaluated are called intellectual or adaptive [3, 4]. Approaches to the creation of adaptive and intellectual technologies for training courses on the Web-platform, that will enable the development of a curriculum based on the level of the learner are porposed in [5, 6]. The plugin for the adaptation of the course structure built in the distance learning management system is described in [7, 8]. It was proposed in [9] to take into account the

* **Proceedings of the XI International scientific-practical conference «Modern information technologies and IT-education» (SITITO'2016), Moscow, Russia, November 25 - 26, 2016**

properties of the learner while creating the test tasks.

The disadvantages of e-learning include the fact that on-screen reading is a labor-intensive process, which creates a large load on the brain. Failure to monitor the psychophysiological condition of the learner may lead to him operating in the system in a non-optimal condition, which may occur due to a low efficiency level during the course of learning over time, as well as, due to the fact that his state before the course was not optimal.

Since psychophysiological state affects effective learning it is relevant to evaluate the state of the learner during training. Proper fulfilment of this task can improve the efficiency of effective learning.

The aim of the work is the development of means to evaluate the psychophysiological state of the learner and e-learning system models considering its state.

In order to attain the goal set, it is proposed to use psychophysiological testing, recording and analysis of bioelectric signals of the learner, state models to assess the ability of the learner to work effectively in the system, fatigue and emotional stress.

Evaluation of the initial state of the learner

Using the evaluation of the initial state will allow to predict the ability for effective learning of the learner before he starts to work on the system. This can be accomplished through the application of the model, which according to the indicator values for cognitive processes, produced as a result of psychophysiological testing, will predict the probability of successful learning.

Based on the data obtained in a series of experiments, a logistic model (classifier) was built for the predicted work with data on the values of performance, memory and attention to be a success. These cognitive processes were chosen based on the fact that they are basic for data processing.

Experimental method

a. Subjects. The subjects were 30 students of the 2-5 courses of Ryazan State Radio Engineering University. The number of male students - 19, female - 11. The average age of the subjects was 20.4 years with a standard deviation of 0.72.

b. Material. Kraepelin test was used in the experiment for ability, Bourdon-Anfimov test for attention and memorization [10] and a test to understand the technical and scientific meaning of the material [11].

c. Investigation procedure. Experiments were carried out for 3 days under the same conditions in groups of 8-12 people. After the meaning was explained and the subjects of the experiment briefed, trial tests for memory, attention and performance were held. The subjects reported the two letters they had to find and delete in the test for attention. Then they had to reproduce 10 two-digit numbers that they had to remember for 30 seconds within 1 minute. The number of correctly reproduced numbers was recorded for each test. After 4 minutes of rest, Kraepelin test was carried out, which involves adding two sequences of numbers, and then, after 4 minutes - Bourdon-Anfimov test was proposed, where for a sequence of letters, two given letters had to be found and deleted in their own way. The total number of additions made and the number of correct / incorrect operations, the number of scanned letters, the number of true / false crossed out letters were recorded. A small unfamiliar text from the technical discipline was proposed as a test for work success evaluation, which they had to learn for 2 minutes, and then reproduce within 1 minute, setting out the basic content and meaning. The result of this test was evaluated on a scale of "Pass/Fail" response for analyzing the text, whereby "Pass" was attributed when a large part of the content and meaning of the original text was transferred.

Obtained results

According to the results of the experiment 30 observation sets were formed, based on which the following parameters were calculated:

x_1 - performance ratio as the ratio of the number of additions made in Kraepelin test for the first half of the test time to the number of operations for the second half,

x_2 – the average addition speed in the Kraepelin test,

x_3 - accuracy index in the test for attention, which is a ratio of the difference between the number of correct letters crossed out and the number of errors (omissions and unnecessary crossed out) to the number of letters that have to be crossed,

x_4 - concentration ratio of attention as a result of the Bourdon-Anfimov test,

x_5 - memory ratio representing the percentage of correctly stored and reproduced two-digit numbers,

Y – the result of successfully reproducing the proposed data on the scale «Pass/Fail».

The results of the subjects of the experiment are shown in Fig. 1. Each point corresponds to the results of a specific subject, the effect of the average speed of addition x_2 and the accuracy indices x_3 are shown for the success in reproducing the data on a «Pass/Fail» scale, whereby the size of the point is directly proportional to the work-ability coefficient x_1. It can be seen that those subjects with low values for precision work, average addition speed and performance coefficient obtained «Fail». Among those with «Fail» there were those with high precision - indices of work and average addition speed, however, they had low indices for attention and memory. In addition, a small number of subjects were unable to understand the meaning of the text submitted, although they had average values for attention and memory.

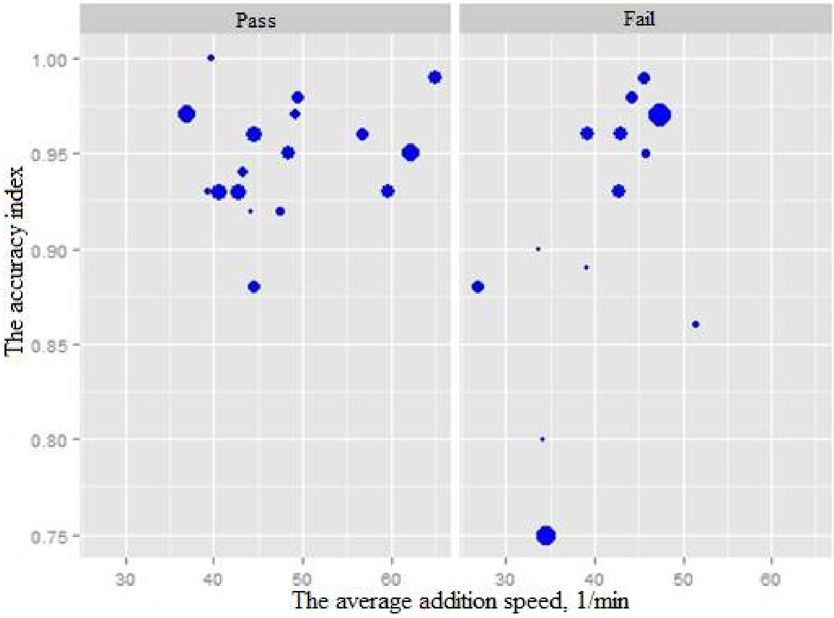

Fig. 1. Results of the experiment subjects

The Y value evaluates the success of the work with data and accepts two values: «Pass» and «Fail». For its analytic description the logistic regression can be used

$$y\left(x_1, x_2, x_3, x_4, x_5\right) = \frac{e^{f\left(x_1, x_2, x_3, x_4, x_5\right)}}{1 + e^{f\left(x_1, x_2, x_3, x_4, x_5\right)}},$$

which depending on the values of x_1, x_2, x_3, x_4, x_5 form the value of y for the interval 0 to 1. The obtained value for y is the predicted probability of successful work with data. In order to move to Y it is required to have a threshold value level Δy and create the value of Y according to the rule:

$$Y = \begin{cases} Fail, if \;\; y < \Delta y; \\ Pass, if \;\; y \geq \Delta y. \end{cases}$$

The regression analysis of data was performed in the statistic packet R. Different possible functions $f(x_1, x_2, x_3, x_4, x_5)$ were considered, where the function for each was defined as a percentage of proper classification and descriptive statistics. It was found that when using a logistic regression type

$$y\left(x_1, x_2, x_3, x_4, x_5\right) = \frac{e^{a_0 + a_1 x_1 + a_2 x_2 + a_3 x_3 + a_4 x_4 + a_5 x_5 \left(1 + a_{15} x_1 + a_{25} x_2\right) + a_{12} x_1 x_2}}{1 + e^{a_0 + a_1 x_1 + a_2 x_2 + a_3 x_3 + a_4 x_4 + a_5 x_5 \left(1 + a_{15} x_1 + a_{25} x_2\right) + a_{12} x_1 x_2}}$$

and a threshold value Δy equaling 0.62, it is possible to properly predict the success of the work with data for 90% of the test subjects. The classification was wrong for 10% of the subjects, which could be linked to the fact that these subjects «carelessly» passed the test. This model has a value of the Akaike information criterion (AIC) equal to 37.975.

We estimate the predictive ability of the model with the help of ROC-analysis. The Fig. 3 shows the ROC-curve. The area under the ROC-curve is equal to 0.9276, which indicates good prognostic properties of the developed model.

If upon prediction, the value obtained is Y = «Fail», this may show the absence of readiness for learning or poor psychophysiological state. In any case, the learner needs to be prepared to work in the system.

This is how a model was obtained to evaluate the success of a learner to effectively process data in the e-learning system according to the valued of cognitive process indices. It is expected to improve the model in the future, performing more experiments and adding other cognitive process indices to the model.

If a browser is used for the e-learning system, the given psychophysiological tests can be in the form of plugins written on JavaScript or PHP. Fig. 3 shows an example of a Bourdon-Anfimov test.

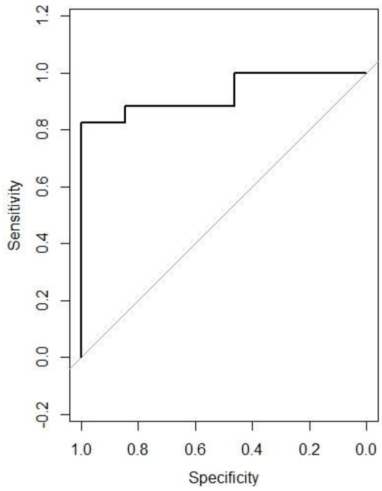

Fig. 2. ROC-curve

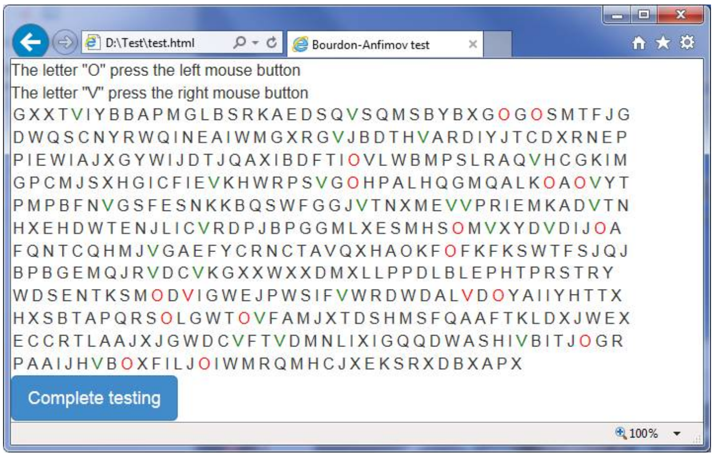

Fig. 3. Appearance of a Bourdon-Anfimov test on JavaScript

Evaluating the current psychophysiological state

Psychophysiological testing cannot be used for the dynamic evaluation of the current psychophysiological state of the learner while working in the e-learning system as the learner needs to be directed to the test as a distraction. Bioelectric signal analysis can be used, in particular, galvanic skin response (GSR). This requires hardware to record the GSR signal and software to analyze it. The software part can be in the form of a plugin in the e-learning system and for a modified manipulator «mouse» can be used as hardware.

It is proposed to use a schematic based on voltage divider from the resistance of the palm portion and a resistor embedded in the arm to record the GSR signal. The distance between the index and middle fingers can be used. In that case, the GSR electrodes may be arranged on the left and right buttons of the manipulator «mouse». A layout of this manipulator was created, allowing the transfer galvanic skin response signals to a PC (Fig. 4).

Fig. 4. Modified manipulator «mouse» layout to record GSR

In order to evaluate the psychophysiological state of the learner based on GSR analysis, two components should be isolated: the tone and the phase. The tone is a low frequency component which characterizes the psychophysiological state of the person. Accordingly, the smaller the resistance of the skin, the higher the activity of the nervous system, reduction of skin resistance indicates that the person is tired. The phase is a high-frequency which characterizes the fluctuation of the signal under the influence of emotionally significant factors. Accordingly, a large number of signal fluctuations per unit of time may be indicative of a negative impact on the current human psycho-emotional factors. Using a combination of tonic and phasic components, a conclusion about the current functional status of the learner can be made. An algorithm can be used for GSR analysis as in [12-14].

Threshold levels for the components of GSR can be set based on the value of the GSR signal at the time of joining the e-learning system. In this case the results of psychophysiological testing with skin resistance values of the learner can compared.

The network model of the e-learning system work

The following algorithm can be proposed for the e-learning system using the developed hardware and software and logistic model to control and evaluate the psychophysiological state of the learner:

1. Implementation of psychophysiological testing before starting to work;
2. Predicting of the success of this training based on the logistic model;
3. If the result of the prediction is poor, the learner is prepared to work in the system until after repeated testing the psychophysiological prediction result is satisfactory;
4. With a satisfactory prognosis the learner is allowed to work in the e-learning system. Based on the analysis and evaluation of GSR level critical levels of the functional status indicators are formed;
5. While working in the system, GSR is recorded and analyzed and the indicators of the current functional status of the learner are controlled. If as a result of such a control, the values of the indicators of the functional state reach critical levels, in particular, fatigue, then the learner is banned from the system and is given an interval for rest and recovery (Fig. 5).

We create a Petri network model to describe the working of the e-learning system based on the psychophysiological state of the learner.

We single out the set $\{B_i\}$ of possible states of the learner in the process of interaction with the e-learning system:

B_0 – the initial state of the learner before entering the system,

B_1 – preparation of the learner for training in case the prediction for successful training is not satisfactory,

B_2 – permission to work in the e-learning system,

B_3 – work in the e-learning system,

B_4 – rest and time-off while working in the e-learning system.

Set $\{d_j\}$ of possible transitions, describing the transition from one state to another, as follows:

d_0 – initial psychophysiological test, allowing to predict the success of learning in the system,

d_1 – beginning of work in the e-learning system,

d_2 – control of the current functional state while working in the system.

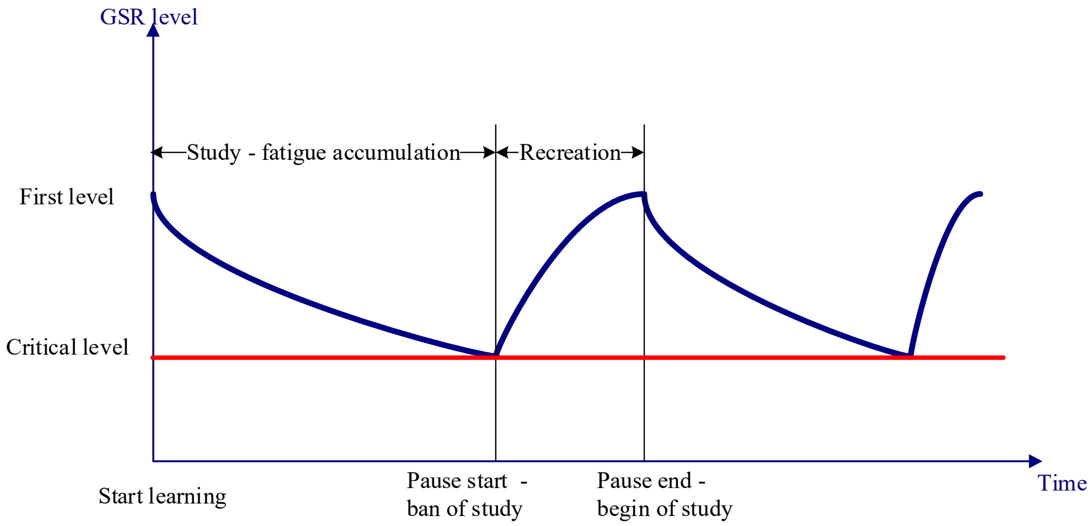

Fig. 5. The principle of using GSR-level changes to organize work in the e-learning system

Then the Petri network model will be a as follows (Fig. 6).

A demo version of the course was created in Moodle system with a module that allows to analyze the level of galvanic skin response, recorded with a manipulator «mouse» and affect the availability of the various components of the course accordingly, denying access for a poor psychophysiological state (Fig. 7).

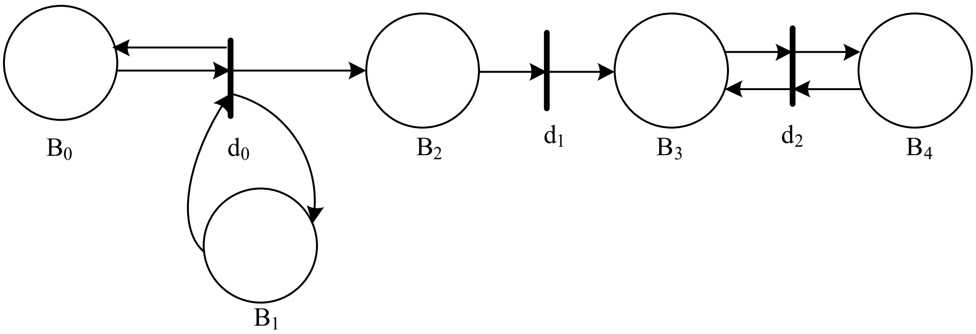

Fig. 6. Petri network model to describe the work of the e-learning system

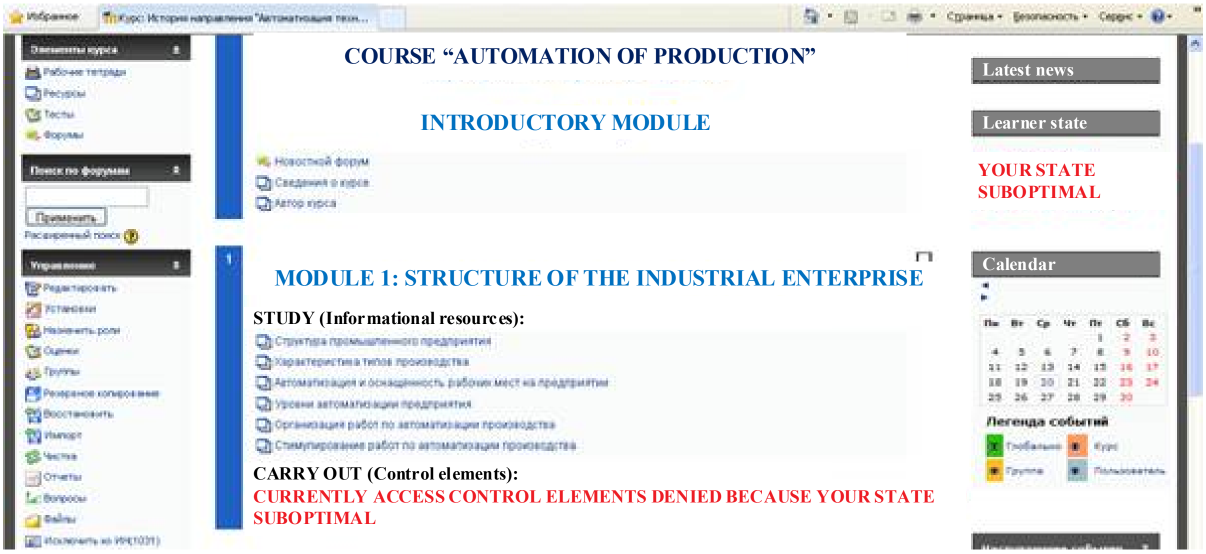

Fig. 7. Course in the Moodle system, taking into account the functional state of the learner

Conclusion

The article showed the means and ways to improve the efficiency of the e-learning process based on the evaluation of the psychophysiological state of the learner. Logistic models were proposed to evaluate the readiness of the pupil to work in the e-learning system. In case the results of prediction are not satisfactory, the student may be asked to train for work in the system and re-tested for the acquisition of the appropriate attitude towards work. In the future we plan to improve the model, conduct a large number of experiments and add more cognitive process indices to the model, including the use of fuzzy logic to build the model.

GSR control of the learner during the learning process will allow to assess the dynamics of his psychophysiological state, including the development of fatigue during training, which later can be used to optimize the e-learning process and the selection of appropriate teaching loads.

The proposed hardware and software are described using the Petri network model, which is intended for the formalization of the system. Using this model, a dynamic description of the working process of the e-learning system can be made, based on the functional state of the learner, to illustrate the transition of the system from one state to another under certain conditions.

References

1. K. Chrysafiadi, M. Virvou, "Dynamically Personalized E-Training in Computer Programming and the Language C," IEEE Transactions on Education, 2013, Volume: 56, Issue: 4, pp. 385-392
2. S. Kopeinik, A. Nussbaumer, L.-C. Winter, D. Albert, A. Dimache, T. Roche, "Combining Self-Regulation and Competence-Based Guidance to Personalise the Learning Experience in Moodle," 2014 IEEE 14th International Conference on Advanced Learning Technologies, 2014, pp. 62-64
3. C. Hampson, O. Conlan, V. Wade, "Challenges in Locating Content and Services for Adaptive eLearning Courses," Advanced Learning Technologies (ICALT), 2011 11th IEEE International Conference on, 2011, pp. 157-159
4. R. Shahin, L. Barakat, S. Mahmoud, M. Alkassar, "Dynamic Generation of Adaptive Courses," Information and Communication Technologies: From Theory to Applications, 2008. ICTTA 2008. 3rd International Conference on, 2008, pp. 1-4

5. H.T. Kahraman, S. Sagiroglu, I. Colak, "Development of adaptive and intelligent web-based educational systems," Application of Information and Communication Technologies (AICT), 2010 4th International Conference on, 2010, pp. 1-5
6. P. Robert, S. Livia, S.M. Cisar, "Examples of adaptive Web-based educational systems," 2009 7th International Symposium on Intelligent Systems and Informatics, 2009, pp. 297-300
7. H. Moutachaouik, H. Douzi, A. Marzak, H. Behja, B. Ouhbi, "Recommendation plugin to facilitate student learning of the platform e-learning," 2011 3rd International Conference on Next Generation Networks and Services (NGNS), 2011, pp. 6-11
8. I.A. Kautsar, Y. Musashi, S.-I. Kubota, K. Sugitani, "Developing Moodle plugin for creating learning content with another REST function call," 2014 IEEE Global Engineering Education Conference (EDUCON), 2014, pp. 784-787
9. I.H. Galeev, "Problems and experience in designing ITS," International e-magazine "Educational Technology & Society (Educational Technology & Society)", 2014, Vol. 17, Issue 4, pp. 526-542. URL: http://ifets.ieee.org/russian/periodical/journal.html
10. A.N. Varnavsky, "Research of preferences dependence in hierarchical text menus of user interface from performance cognitive processes," 2016 Cognitive Sciences, Genomics and Bioinformatics (CSGB), 2016, pp. 1-5
11. A.N. Varnavsky, "Research of preference in playback speed of learning video material depending on indicators of cognitive processes," 2016 Cognitive Sciences, Genomics and Bioinformatics (CSGB), 2016, pp. 1-4
12. D.G. Domingues, C.J. Miosso, A.E. Paredes, A.F. Rocha, "Module for the acquisition and processing of biological signals related to the emotional state," 2011 Pan American Health Care Exchanges, 2011, pp. 237-238
13. F. Liu, G. Liu, X. Lai, "Emotional Intensity Evaluation Method Based on Galvanic Skin Response Signal," 2014 Computational Intelligence and Design (ISCID), 2014 Seventh International Symposium on, 2014, Volume 1, pp. 257-261
14. A.N. Varnavsky, "Automated system for correction of functional state of production workers," 2015 Control and Communications (SIBCON), 2015 International Siberian Conference on, 2015, pp. 1-4

Поступила: 16.10.2016

About the author:

Varnavsky Alexander Nikolaevich, Ph.D., assistant professor of department of automation of information and technological processes Ryazan State Radio Engineering University, varnavsky_alex@rambler.ru.

Сведения об авторе:

Варнавский Александр Николаевич, к.т.н., доцент кафедры автоматизации информационных и технологических процессов Рязанского государственного радиотехнического университета, varnavsky_alex@rambler.ru.