Concept of mobile operator position based on neurocomputer interface and augmented reality

S A Kizilov\(^1,2\), M S Nikitenko\(^1,2\) and B Neogi\(^3\)

\(^1\)Federal Research Center of Coal and Coal Chemistry, Siberian Branch of the Russian Academy of Sciences, 18 Sovetskiy Ave., Kemerovo, 650000, Russia
\(^2\)T.F. Gorbachev Kuzbass State Technical University, 28 Vesennyaya Street, Kemerovo, 650026, Russia
\(^3\)CoE & CII Centre for Innovation, JIS College of Engineering (JIS Group India), Block A, Phase III, Dist. Nadia, Kalyani, West Bengal, 741235, India

E-mail: schum24@rambler.ru

Abstract. The concept of creating a mobile operator position for the mining industry based on combining the technologies of the neurocomputer interface and augmented reality is proposed.

1. Introduction

The readily available and rich mineral deposit of the mining complex in Russia and abroad is now almost exhausted. Reserves that are characterized by complex mining and geological conditions are involved in development - stratification depth increases, occurrence is noted in steep thick seams, high gas content of coal seams. However, the mining equipment used and modern mineral extraction technologies from thick and steeply inclined thick coal seams are not without the constant presence of people in the longwall area, which is due to the complexity of the mining technology. In this case, mistakes in mining machine control or the influence of the human factor on the quality of machine control of a more complex technological process, accordingly increases the risks of occurrence of emergency situations. Therefore, the further development of the mining industry and the improvement of the mining safety system depend to a greater extent not only on the use of new modern types of equipment and processing technologies. An important factor is the dynamics and quality of creation, as well as the depth of introduction of modern automated control systems for technological processes and dispatching of mining operations.

The need to increase the efficiency of the development of difficult-to-extract minerals in complex mining and geological conditions and in mines dangerous for gas and dust creates the need for a transition to the “manless face” extraction technology for automated and automatic equipment brought to the level of robotic complexes [1].

Based on the foregoing, not only the development of new technical solutions for working out thick and steeply inclined mineral deposits [2], but also modern automated controls and dispatching equipment of the mining complex is topical. Developed new technological development schemes [3] and technical equipment for extracting minerals [4, 5], automated control systems of mining equipment and its diagnostics [6–11] allow to form the basis of the concept of creating robotic complexes for mining and extraction of reservoir deposits of minerals (coal, diamond-bearing ore, etc.) with a control system that takes into account, including the state of the mountain massif and its dynamic manifestations. The first step to its creation is the automation of process control during the
development of thick coal seams with top coal caving technology (LTCC), which should concern both
the operational withdrawal and the control and dispatching system of the equipment of the longwall
complex.

2. Methods of research
With regard to the control and dispatching system for the operation of the longwall complex
equipment, when working out thick coal seams with top coal caving, we note that the classification of
the causes of emergencies with the influence of the human factor into three main categories:

- accidental error, inattention or weakening of control over the situation;
- low qualification of maintenance staff;
- a gross violation of safety precautions, often combined with the first two points,
makes it possible to draw a conclusion that modern dispatching systems have two serious drawbacks:
1 – stationary place of the operator (means the presence of devices or monitors with indication of the
current state of the system and a fixed location of controls); 2 – high requirements for the qualification
and physical condition of the operator.

In this context, the hardware based on the Brain computer interface (BCI) is very promising and
relevant for building an automated control system, in conjunction with augmented reality equipment.

Currently, the authors, in conjunction with JIS Collage of Engineering, where specialists are
already working on the study of basic BCI-based control modules [9, 10], are working on the concept
of the mobile operator's position and integration of BCI equipment and augmented reality into the
automated control system. In addition, it is possible to expand the management methods by using the
electromyography method (EMG).

The main aim is to organize the work of the dispatcher of the automated control system for
 technological processes of underground mining of mineral deposits at a new technical level, without
permanent location in the workplace, with a reduction in the probability of making an error, loss of
visual contact with the parameters of the control object, based on virtualization of control and
monitoring instruments.

The main idea is combining the technologies of the neurocomputer interface, electromyography
and augmented reality for the control system of technological processes of underground mining of
mineral deposits.

3. Results and discussion
The ability to display information about the state of the complex of equipment directly in front of the
operator with the rendering of interactive controls of the complex is provided by the augmented reality
systems, access to the main emergency management functions takes place through the adaptive
automated control system based on the BCI control interface technology. The system based on BCI
allows you to get an almost instantaneous signal from the operator and perform a specified action,
which is important in an emergency situation. In this case, the operator does not even need to simulate
pressing the “emergency stop button”, the general scheme of the mobile workstation of the operator
longwall complex is shown in figure 1.

The mobile operator's position of the operator allows solving a number of problems related to the
safety of work in underground workings. Such problems as loss of eye contact for a long time with
indicators that display information about the status of the working complex are being solved. There is
an opportunity to better equip the operator's workplace ergonomics and reduce his fatigue. The
operator is given the opportunity to make control manipulations at any point in the control room, and
not only when he is directly at the stationary console.

The control of the equipment within the framework of the proposed concept takes place through the
interaction of the operator's hands with virtual keys displayed on the display of the augmented reality
headset, the operator's actions are monitored by two different systems, the data from which are
compared and their verification takes place.
The first system is a standard method for virtual and augmented reality systems, operating on the basis of information received from built-in video cameras and position sensors. But for high accuracy of operation, such a system requires the presence of markers on the monitored parts of the body, which are not very convenient in everyday use.

The second system is based on the use of methods of electromyography, the system tracks the impulses of the muscular system of the operator and translates them into commands for controlling the technique. Such a system, although it requires the mounting of sensors on the operator’s body, but they should not be felt if installed properly.

It is worth noting that the technical means based on the neurocomputer interface, allowing the introduction of an additional control channel from the dispatcher or operator (user) of equipment, have recently entered the market, (since 2003, Mindball (Interactive Productline), MindSet, MindWave (NeuroSky), Neural Impulse Actuator (OCZ Technology), EPOC and Emotiv Insight (Emotiv Systems), Mindflex (Mattel), XWave headset (PLX Devices), MyndPlay BrainBand (MyndPlay), OpenBCI (OpenBCI project), Muse (InteraXon) etc. insufficiently researched and tested in real conditions in the direction of application in industrial enterprises for a solution for giving dispatching. In addition, the psychophysiological state of the operator has a significant influence on the quality and efficiency of generation of control actions.

4. Conclusion
The proposed concept of mobile operator position makes it possible to organize the work of the dispatcher of the automated control system for technological processes of underground mining of mineral deposits without permanent location in the workplace, with a reduction in the probability of making an error, loss of visual contact with the parameters of the control object.

Acknowledgement
The project was financially supported by the Ministry of Education and Science of the Russian Federation within the Federal target program ‘Research and development of priority directions of scientific-technological complex development of Russia for 2014-2020’ (agreement No. 14.604.21.0173 from 26.09.2017, unique ID RFMEFI60417X0173).

References
[1] Ermekov T E, Nesipbaev Zh S and Sarsenbaev T U 2001 Works of the University 1 46–47
[2] Malakhov Yu V 2017 Proc. of the Int. Sci. and Practical Conf. in Innovations in the Fuel and Energy Complex and Engineering pp 62–68
[3] Klishin V I 2013 Mining Informational And Analytical Bulletin 6 36–47
[4] Klishin V I and Kokoulin D I 2015 A Powered Supor for Working out Thick Steep Coal Seams with Sublevel-stopping patent RF no. 1604472 U1
[5] Klishin V I, Anferov B A and Kuznetsova L V 2017 Proc. of the Int. Sci. and Practical Conf. in Innovations in the Fuel and Energy Complex and Engineering pp 57-63
[6] Roiter M, Wexler J and Kurfürst V 2007 Industry of Kazakhstan 9 34–40
[7] Sadovets V Yu and Kizilov S A 2016 Technologies and Materials 3 4–7
[8] Nikitenko M S, Malakhov Yu V, Neogi B, Chakraborty P and Banerjee D 2017 IOP Conference Series: Earth and Environmental Science 84 012002
[9] Nikitenko M S 2016 IOP conference series: Earth and environmental science 84 012007
[10] Neogi B et al 2016 Cognitively Velocity Controlled Vehicle Patent IND File no. 201631017186 Indian Patent Journal no. 26/2016 http://www.ipindia.nic.in/writereaddata /Portal/IPOJournal/1_350_1/part1.pdf
[11] Neogi B et al 2016 Thought Concentration Controlled Dexterous Prosthetic Arm for Handicapped. File no. 201631017174. Indian Patent Journal no. 26/2016. http://www.ipindia.nic.in/writereaddata/Portal/IPOJournal/1_350_1/part1.pdf