The modern information technologies in construction for improving occupational safety

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Abstract. Today, construction takes first place in the number of industrial accidents, including severe and fatal ones. Inconsistency of jobs, work at height, work in extreme conditions, adverse weather factors, all this and much more is the cause of traumatic factors. The article discusses the implementation aspects of modern information technologies that allow you to assess the psycho-emotional state of the employee in real time and make timely decisions on the organization of work safety. Based on the results of the analysis, a "Psychophysiological Monitoring System" is proposed. Existing analogues of such systems are not used in production, more often they are designed to assess the physiological state of athletes. The technology of analysis and assessment of the state of workers is presented, which a complex of interrelated parts is such as: the main sensor module, local receiving and transmitting device, stationary receiving and processing device, sensors for evaluating external conditions, a database and a server for data transmitting and processing. Based on the developed hardware-software complex, measures are proposed for the prevention of injuries in construction during construction and installation works on height.

1. Introduction
Today, occupational risk assessment is an integral part of labor protection at the enterprise. The significance of this innovation is determined by the transition of the domestic economy to a risk-based approach.

The popularization of professional risk assessment is associated with industrialization, during the active use of technologies, equipment, biochemical substances, various energy sources, all areas of activity are at risk.

A statistical study of the causes of injuries shows that the introduction of improved equipment and mechanisms is not a key factor in reducing accidents and injuries. Only part of the technical imperfection is associated with a significant number of accidents, the main cause of technological accidents is a person (80-90%), namely, the adoption by him of incorrect or inappropriate actions in this situation [1]. Erroneous actions are usually unintentional, that is, a person is making deliberately erroneous actions, regards them as correct and suitable for a given situation.

The reasons for this behavior can be both insufficient qualifications and lack of sufficient information to make a decision. This is especially clearly seen in conditions of time pressure, the need for quick decision-making in an emergency.
To prevent erroneous actions, timely identification of potentially dangerous conditions of people is necessary, namely when a person is confused or excited and may make a mistake. At the moment, labor protection specialists do not have enough information to identify these conditions. Effective forecasting requires the development of information support for timely decision-making and the prevention of erroneous actions that result in an accident or injury.

2. Methods
Modern tools for predicting incidents and unsafe employee behavior are algorithms created on the basis of various technologies that combine the capabilities of a computer and the Internet. At the same time, intelligent systems based on neural network models, Markov networks, Bayesian networks and other models are used. There are attempts to create models of unsafe behavior of workers based on an analysis of indicators of their behavior and working environment, such as the level of management control, working conditions, the safety management system, the level of employee participation, knowledge of safety requirements, safety attitudes, motivation, resource allocation and production stress.

The following technologies are used in the basis of foreign expert systems [2-13]:
- Fault Tree Analysis (FTA);
- Failure Mode and Effects Analysis (FMEA);
- Fuzzy Analytic Network Process;
- Bayesian Networks;
- Graphical Evaluation and Review Technique;
- Neural Networks.

All of the above listed methods of analyzing and forecasting incidents, erroneous actions of personnel, accidents and emergency situations make it possible to create integrated software products that are designed to facilitate occupational safety control and management processes in enterprises, hazardous production facilities, etc.

3. Results and discussions
The relevance of occupational injuries affects all countries of the world. According to the ILO, annually about 2.3 million people die from industrial accidents, which is about 3.4% of the total mortality per year [1].

In terms of occupational injuries, Russia is 2.5–3 times ahead of the EU countries. 6 deaths per year per 100 thousand people, while for for EU countries the data is from 0–3, for the UK – 0.8, Ukraine – 3.8, Kyrgyzstan – 4.1, Lithuania – 4.2 Kazakhstan – 5, Moldova – 5.2. Despite the improving dynamics, our country remains the leader among post-Soviet countries in terms of mortality in the workplace [1].

According to the ILO, the most dangerous are the manufacturing and construction sectors, followed by transport, agriculture and mining.

One of the main factors holding back the technological and economic process in Russia is the percentage of occupational injuries.

The International Labor Organization provides the following statistics, according to the number of victims, the dynamics are presented in Figure 1.
And despite the increase in cash funding for this period spent on labor protection measures per worker, the problem of injuries remains relevant.

This can be explained by the fact that the main cause of an industrial accident, including fatal cases, is the human factor, which includes a lack of qualified personnel, a lack of knowledge in the field of safe work, personal reasons, psychoemotional causes of the individual, lack of motivation and much other [2-5, 24].

The distribution of accidents by cause is provided in Figure 2.

Accordingly, the main cause of all accidents is the person himself and to reduce and measures to reduce injuries should be aimed at the employee [6, 7].

Figure 1. The dynamics of industrial injuries in 2000–2018 years.

Figure 2. Distribution of causes of severe accidents.
The proposed project relates to medical equipment, and more specifically to the technology of industrial medicine, and specifically to a system for monitoring physiological parameters in order to determine the psychophysiological state of workers in the construction industry [8-25].

The feasibility of this development is as follows:
1) Cost reduction (transformation of sick employees, payment of her disability, compensation, the search for new personnel, and so on)
2) Increasing the efficiency and productivity of production (the need to timely carry out preventive measures to support the health conditions of employees for their effective work).

The closest analogues in terms of functionality, but not in scope are the ZephyrTM PSM Training system and BioHarness®.

These systems are aimed at tracking the performance of athletes, to create effective training and the correct redistribution of the body's forces. Accordingly, these systems include the necessary sensors of physiological indicators that are in demand for tracking the progress of training, but they cannot be adapted to control production workers, since their functionality is not adapted for this. Therefore, the development of the “Psychophysiological Monitoring System” was based on the results of existing developments, but it is a unique system adapted for monitoring psychophysiological indicators, which takes into account environmental parameters and statistical data. The list of patents is RU 2677061, US 20130023739, US 20140340219, US 20140343448, US20130144130, US 20120165645.

The psychophysiological monitoring and warning system may include one or more wireless sensors that perceive and process information from sensors about the physiological state of a person. The processing performed by the sensors includes a function for comparing values, after which a signal is generated on the device of the controlling person. To reduce the amount of information, a signal can be received by the controlling person only when the indicators of the state of human health deviate from standard values. The controlling person may be the person responsible for labor protection or a specially authorized employee who regulates work efficiency and monitors the health of the worker. The transmission of contextual signals about the deviation of the psychophysiological state of the employee will allow the controlling person to take preventive measures before the onset of injury.

An example of a remote system for monitoring physiological parameters is shown in Figure 3.

![Figure 3](image)

**Figure 3.** The general principle of the "Psychophysiological monitoring system".
The system includes people "a", each of whom wears a sensor "b". The "b" sensors transmit signals through the "c" wireless network. The transmitted signals can be transmitted to the local computing devices "e", "d". As these devices smartphones, tablets and any other convenient computing devices connected to the server "f" through the network "k" can be presented. These devices are equipped with specialized software that processes and visualizes the received data (for example, ProRAE Guardian or Welltory programs). Additional "q" sensors that measure the microclimate of the working medium (air temperature, relative humidity, resulting room temperature, air velocity and local asymmetry of the resulting temperature) can also interact with server "f" through the network "k". The server "k" stores the received data and performs a detailed analysis of the monitoring data of physiological parameters, and then provides them to the local devices "e", "d" at the request of the controlling person. Further, the server can carry out further communication with a remote computer, which will allow remote monitoring to an interested person, such as the head of the enterprise. Also, the server "f" can communicate with various databases in which the collected data can be stored.

Each sensor unit "b" is capable of simultaneously sensing several physiological parameters. Since the device is intended for people employed in work with special conditions, the sensor should include all the necessary sensors of physiological indicators sufficient for quick response, and the device should not be bulky and uncomfortable when conducting work. These indicators are:

- Heart rate
- Breathing rate
- Body temperature
- Heart rate variability
- Skin-galvanic reaction
- Body position in space

The sensor module is equipped with radio communications for wireless data transmission and command reception, which can be done using the personal Bluetooth frequencies (for example, the RN4020 model module), as well as these units will be equipped with an individual notification system of the one directly working by sending an audio signal when registering hazardous to humans health conditions. The sensor module is also equipped with electronic circuits, including microcontrollers, memory, and sensors for measuring physiological parameters, a power source, sound and light indicators and power buttons.

4. Summary
As a result, a “Psychophysiological Monitoring System” was developed, the purpose of which is to continuously record the physiological indicators of the worker associated with his psycho-emotional state, transfer, analyze and display the results on local or stationary devices to employees responsible for safety. If a deterioration in the state of health is detected, depending on the indicator, the strength of its change and individual indicators, measures should be taken to provide medical or psychological assistance or other organizational measures should be taken (break, transfer to another type of work, exemption from work for a certain time, etc.).

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