Abstract

Abstract of the dissertation of Artem Valerievich Chernukhin on the topic: "Automated system for forecasting the technical condition of industrial equipment based on artificial intelligence."

Relevance of the research topic. The development of an automated system for predicting the technical condition of industrial equipment based on artificial intelligence (AI) methods has become particularly relevant in recent years due to a number of factors. Firstly, the ever-increasing complexity of modern industrial equipment, characterized by an increasing number of sensors, actuators and control systems, makes classic monitoring and analysis of the technical condition of equipment in real time increasingly labor-intensive, and in some cases impossible without the use of solutions based on AI methods. In addition, the introduction of Industry 4.0 and global digitalization have led to a significant increase in the volume of data generated by industrial equipment. Consequently, automated AI-based forecasting systems can process and analyze this data to identify patterns, trends and anomalies, which allows for early preventive maintenance and reduced downtime. Also, the development of an automated forecasting system will allow the industry to reduce costs associated with equipment maintenance, repair and replacement. Companies that implement AI-based forecasting systems can gain a competitive advantage by increasing overall efficiency and productivity, industrial and environmental safety, identifying potential equipment failures that can lead to accidents or environmental disasters. Finally, an important factor in the relevance of this task is that unexpected malfunctions and equipment failures at hazardous production facilities can lead to serious injuries or even human casualties. Thus, this task is extremely urgent and the mass implementation of such systems at enterprises will lead to a significant increase in the industrial potential of the state as a whole.

The aim of the study is to develop an automated system for predicting the technical condition of industrial equipment based on artificial intelligence methods.

To achieve the set goal, it is necessary to solve the following tasks:

1. Analyze domestic and foreign analogues.

2. Develop a new flexible functional structure of an automated system for predicting the technical condition of industrial equipment.

3. Develop forecasting models based on artificial intelligence methods that can predict possible malfunctions and failures of industrial equipment. This requires training the models on historical data on malfunctions, failures and the operating condition of the equipment.

4. Conduct an analysis of the technical diagnostics object and collect a data set with information on malfunctions and failures of industrial equipment over a long time interval with a low proportion of malfunctions, and process the data.

5. Implement the functional structure of the automated forecasting system, including developing a web service that implements the ability to store and process data in real time, with a user-friendly interface for end users.

6. Introduce into the system the functionality of retraining models on large volumes of continuously incoming current data in automatic mode without involving developers.

7. Conduct comprehensive testing of the system in conditions close to reality.

Scientific novelty. In the process of completing the dissertation, new scientific results were obtained for the first time:

1. A new functional structure of an automated system for forecasting the technical condition of industrial equipment was developed, including subsystems for data import, data storage and processing, forecasting, data display, and a unique model management subsystem that allows for additional training of models taking into account the dynamically changing conditions of the production process.

2. An integrated approach to forecasting the technical condition of industrial equipment was proposed, consisting in setting problems for forecasting malfunctions and failures, as well as assessing the remaining service life of the equipment, and the possibility of implementing the formulated problem statements using artificial intelligence methods was scientifically substantiated.

3. A new method for analyzing and processing data on industrial equipment malfunctions was proposed and implemented, taking into account the specifics of use in an automated forecasting system, consisting in pre-processing data in real time at high speed and accuracy, taking into account their physical nature.

4. A new algorithm for diagnosing technical systems using a unique ensemble approach has been proposed, based on which new models for predicting faults and failures of industrial equipment with high accuracy metrics have been developed and trained.

5. A new algorithm for predicting the remaining service life of equipment has been proposed and implemented, based on modern neural network architectures, showing high accuracy metrics for a forecasting horizon of one month.

6. A new approach to comprehensive testing in conditions close to real industrial operation has been proposed and tested, consisting of a comprehensive simulation of the working environment, load testing on historical data and verification of integration with industrial systems, which has shown high efficiency of the system in the context of tasks of automating the monitoring of the technical condition of industrial equipment.

The theoretical significance lies in the development of methods for constructing intelligent systems for automated prediction of industrial equipment failures.

The practical significance lies in the fact that the developed automated prediction system is of great interest to developers of complex automated production process control systems, since it performs the functions of collecting, storing and processing a large amount of information on the state of industrial equipment, predicts its failures in real time with high accuracy, and also has a flexible functional structure.

The system is capable of promptly providing decision makers with access to forecasts and recommendations for preventing failures and malfunctions based on a large array of data that the operator cannot effectively process independently. This is achieved, among other things, due to the ability to retrain models automatically without involving developers on an accumulating array of data.

The provisions submitted for defense:

- a mathematical model based on "soft voting" between the logistic regression algorithm, the support vector machine and the convolutional neural network, capable of solving the problem of predicting industrial equipment failures with high quality;

- a mathematical model based on the isolation forest algorithm used to search for abnormal operating modes, as well as the LSTM (Long short-term memory) neural network as a classifier, capable of solving the problem of predicting industrial equipment failures with high quality;

- an automated system for predicting industrial equipment failures and malfunctions, which has a unique flexible functional structure and includes import, storage and processing data, forecasting, model management and display subsystems;

- the results of testing the automated system on tasks close to real ones, confirming the high stability of the system.