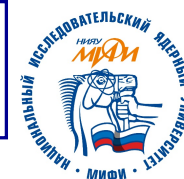


Analysis of using of neural networks for real-time process control.

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ABSTRACT

Machine learning is one of the key technologies of the current scientific and technological revolution. Despite the fact that research in the field of "intelligent" control systems began in the last century, real-time control systems based on machine learning, specifically neural networks, began to be actively implemented only in the past decade. In this paper, the authors analyze the current state of the problem of using real-time control systems based on neural networks and using machine learning in real-time control systems.

INTRODUCTION

Artificial Intelligence (AI) is one of the key technologies in Industry 4.0, along with robotics, the Industrial Internet of Things (IIoT) and Big Data. The rise in popularity of machine learning came after the publication of an article by Jeffrey Hinton et al. in 2006, in which they showed how to train a deep neural network. This method is used to solve a large number of tasks - from image classification tasks to tasks of developing a car autopilot. This technology finds its application in complex technical objects with real-time control systems. In combination with other technologies of Industry 4.0, the following trends of application of AI in industry can be distinguished: digital twins of technological objects, data mining coupled with IIoT, and computer vision.

DIGITAL TWINS OF TECHNOLOGICAL OBJECTS

A digital twin (DT) is a software analogue of a physical device that simulates internal processes, technical characteristics and behavior of a real object under the influence of interference and the environment. An important feature of the digital twin is that information from sensors of a real device operating in parallel is used to set input influences on it. DT improves the process of managing a complex system at all stages of its life cycle: from design to decommissioning.

With the help of information collected by the elements of the IIoT of a complex system (for example, as Tesla does with their cars), it is possible to predict failures and estimate the residual resource of equipment, optimize the operation process (for example, by adjusting automatic regulators). Full-scale mathematical models describing the object, or mathematical models based on machine learning are used in solutions of these problems. Application of AI allows avoiding the time-consuming process of building an accurate model without loss of accuracy, but large data sets are required to train it (Big Data). One of the ways to get around this difficulty is to train the neural network on accurate mathematical models using powerful graphics accelerators.

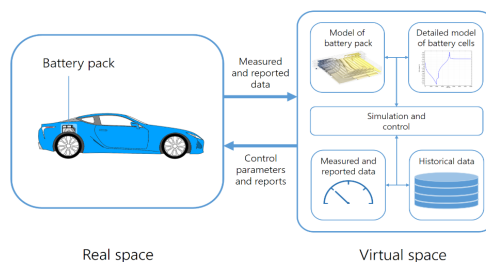


Fig. 1. Digital twin of Tesla battery pack

IIoT

Industrial Internet of Things, IIoT - Internet of Things for industry application - a system of interconnected computer networks and connected industrial facilities with built-in sensors and software for collecting and exchanging data, with the possibility of remote monitoring and control in an automated mode, without human participation. There is IIoT architecture on fig. 2.

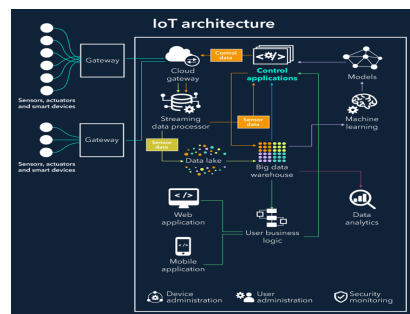


Fig. 2. IIoT architecture

COMPUTER VISION

In industry, computer vision is usually used to classify raw materials on production lines. However, control systems with computer vision are used not only in industry - for example, the existing developments on autopilot are based on the recognition of AI objects on the road. Fig. 3 shows a perspective view of the NVIDIA autopilot.

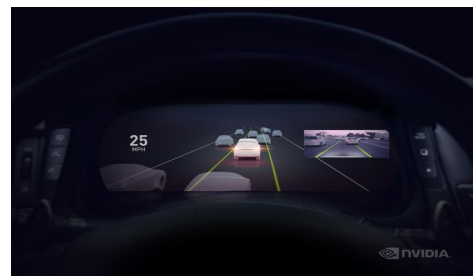


Fig. 3. Computer vision in NVIDIA autopilot

CONCLUSIONS

Artificial Intelligence is one of the key technologies in Industry 4.0. This technology finds its application in complex technical objects with real-time control systems. In combination with other technologies of Industry 4.0, the following trends of application of AI in industry: digital twins of technological objects, data mining coupled with IIoT, and computer vision.

The use of neural networks as control systems for real equipment is hindered by the following fundamental difficulty, which is relevant at the moment - no one knows how a neural network with a large number of hidden layers makes decisions. It is the interaction of computations within a deep neural network that is crucial for making complex decisions, but these computations are a web of mathematical functions and variables [10]. We cannot use the network as a control system for a real complex system (for example, an NPP power unit) due to safety reasons. At the moment, this problem remains unresolved.

REFERENCES

1. Geron, A.: Hands-On Machine Learning with Scikit-Learn and TensorFlow, O'Reilly Media, Inc., Boston (2017).
2. Patel, A.R., Ramaiya, K.K., Bhatia, C.V., Shah, H.N., Bhavsar, S.N.: Artificial Intelligence: Prospect in Mechanical Engineering Field—A Review. In: Kotecha K., Puri V., Shah H., Patel R. (eds.) Data Science and Intelligent Applications. Lecture Notes on Data Engineering and Communications Technologies, vol. 52, pp. 267–282. Springer, Singapore (2021).
3. Swami M., Verma D., Vishwakarma V.P.: Blockchain and Industrial Internet of Things: Applications for Industry 4.0. Bansal P., Tushir M., Balas V., Srivastava R. (eds.) Proceedings of International Conference on Artificial Intelligence and Applications. Advances in Intelligent Systems and Computing, vol. 1164, pp. 279–290. Springer, Singapore (2021).
4. GE Digital. Digital twin, <https://www.ge.com/digital/applications/digital-twin>.
5. Tesla. About Tesla, <https://www.tesla.com/about>.
6. Cambashi, Industry Knowledge for Business Advantage, <https://cambashi.com/siemens-goes-all-in-on-digital-twin/amp/>.
7. Atomic Expert and Atomic Energy journal, Digital twins in nuclear industry, http://atomicexpert.com/virtual_npp_rosatom.
8. Nasiri, A., Omid, M., Taheri-Garavand, A. An automatic sorting system for unwashed eggs using deep learning. Journal of Food Engineering 283, 110036 (2020).
9. NVIDIA DRIVE Autopilot, <https://nvidianews.nvidia.com/news/nvidia-introduces-drive-autopilot-worlds-first-commercially-available-level-2+-automated-driving-system>.
10. Knight W. 2017 The Dark Secret at the Heart of AI MIT Technology Review May/June, <https://www.technologyreview.com/2017/04/11/5113/the-dark-secret-at-the-heart-of-ai/>, last accessed 2017/04/11.