DOI: 10.63550/ICEIP.2025.52.71.073

The Opportunity of Numerical Simulation, Fuzzy Logic Systems and Using Neural Algorithm for Wind Farms in Agro Industry

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Key words: wind farms, numerical simulation, neural networks.

Abstract: The article discusses a neural network embedded as a model in the database program that can process more and more cases (situations), scaling the database by exchanging with similar complexes in the SCADA system. A wind turbine with large-chord blades spins up independently, and then the blade chord decreases and automatically adjusts to the corresponding wind speed with the achievement of the maximum coefficient Cp. In a storm wind, the blade chord decreases even more in size, interceptors are released, breaking the blade. The described actions are performed by a subordinate object (the wind turbine blade mechanization control system) under command and full control with the corresponding case registration by the database, based on artificial intelligence algorithms. Thus, the maximum coefficient Cp is achieved in the entire range of operating wind speeds, and the range itself is significantly expanded.

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1 INTRODUCTION

Methodology as a doctrine is a sequence of methods for designing (developing) a target object. In this case, the target object should be a device capable of fundamentally and universally solving all of the listed systemic problems of a wind turbine without exception, related to ensuring the optimal current speed of the wind turbine in all operating modes (Al-Bahadly, 2007). It is assumed that such a solution is possible with the help of mechanization of the wind turbine blade, i.e. adding additional components of the plumage with the ability to activate and deactivate them depending on the current operating mode). However, the problem of timely rapid response to rapidly changing aerodynamic conditions (namely, they are the subject of study for determining operating modes) should be solved by making an operational decision at the level of the wind turbine control object and/or base using artificial intelligence, which the base has, with further transmission of the command to the subordinate object (i.e. the blade/wing mechanization control system). At the same time, the neural network embedded in the database operating program as a model can process more and more cases (situations), scaling the databases by exchanging with similar complexes in the SCADA system (Khramshin, 2017).

2 MATERIALS AND METHODS

Thus, the methodology for developing mechanization elements should be applicable to wind power, and the presented methods can be used both in a certain sequence and in combinations. The methodology is formed on the basis of a system of methods. The efficiency of the mechanization elements depends not only on the level of optimization of the parameters and characteristics of the equipment components, but also on the optimization of the entire hardware and software complex, including all systems - the base, the subordinate object, the communications system. When forming target functions using a digital method, it is possible to level out analog inaccuracies caused by sensor readings (Hughes, 2006).

3 REVIEW

At present, there is a small set of methodologies for developing technical devices in the field of wind energy. These publications attempt to increase efficiency while expanding the range of operating winds by introducing a non-zero blade installation angle for independent start-up, using aerodynamic regulators for braking in storm winds. However, the introduced technical solutions do not provide for the presence of mechanization elements. Nevertheless, this is the only scientific and technical approach to the methodology of developing devices identified in the literature. Other publications in the Russian Federation are reviews, developments and studies of various designs of technical devices, but not a methodology. Foreign publications are mainly devoted to the development (macro- and micro-sitting) of wind farms. As a rule, in such publications, the term "methodology" most often means such concepts as "method, approach, path, way", etc. In reality, a description of the methodology as a doctrine or a set of methods for developing wind turbines has not been found abroad (Sierra-Garcia, 2022, Osintsev, 2021).

4 PROBLEMS

Thus, a preliminary analysis of the literature shows that there is no methodology (i.e., a sequence of methods) for developing wind turbine mechanization systems in the agricultural industry in the world. There are also no technical solutions for using mechanization in the working bodies of wind turbines. Accordingly, there is no concept of a base that would operate on the basis of artificial intelligence algorithms, trained to make optimal decisions based on the development of a neural network (Phelps, 2013). To form a methodology, it is necessary to conduct a preliminary functional analysis of the family of devices that are the Subordinate object, as well as devices that form a complex mechanization operating in a wide range of input effects. On this basis, mathematical modeling of hardware and software systems is carried out with subsequent processing of the analysis of the state of the Subordinate object and the external environment and further issuance of control actions. It is necessary to form technological approaches to the implementation of the technological process of the mechanization elements, to justify the feasibility of the structural and functional development of the

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technological concept with the identification of advantages over alternative approaches (if any are identified). The development is applied to wind turbines used in the agricultural industry.

5 NUMERICAL SIMULATION METHOD

Computer modeling is a less expensive and more flexible way to evaluate the characteristics of a target object with a number of assumptions and limitations. In this regard, this approach is the most appropriate in terms of aerodynamic analysis of mechanization elements. Software for numerical modeling is selected based on the developer's experience. Note 1: To create a 2D or 3D model in the software, it is necessary to either create such a model in a CAD system (e.g. SolidWorks, FreeCAD, Autodesk AutoCAD, LibreCAD, nanoCAD, Autodesk Inventor, etc. based on the developer's experience). Note 2: Setting up the software includes selecting a turbulence model, which seriously affects the result (Thakur, 2016).

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6 FUZZY LOGIC SYSTEM

A branch of mathematics that is a generalization of classical logic and set theory, based on the concept of a fuzzy set, first introduced by Lotfi Zadeh in 1965 as an object with a membership function of an element to a set that takes any values on the interval [0,1], and not just 0 or 1. Based on this concept, various logical operations on fuzzy sets are introduced and the concept of a linguistic variable is formulated, the values of which are fuzzy sets.

The subject of fuzzy logic is the study of reasoning under conditions of fuzziness, blurriness, similar to reasoning in the usual sense, and their application in computing systems.

In relation to wind turbines, fuzzy logic will work as follows. After all the experiments, data on air flows near the wing/blade and the necessary effects on the control elements will be collected. Conventionally, if the values of the characteristics of the air flows at a given moment or their totality are greater or less than certain ones, then the mechanization element will turn in a certain way.

The advantage of this approach is simplicity, it does not require complex calculations, and processing is possible on the device itself without the need to send data for training to the database. The disadvantage of this approach is the excessive number of all possible combinations of flow characteristics and effects on control elements (Sierra-Garcia, 2022, James, 2017).

7 NEURAL NETWORK MODELS

The standard structure of a neural network may look like this.

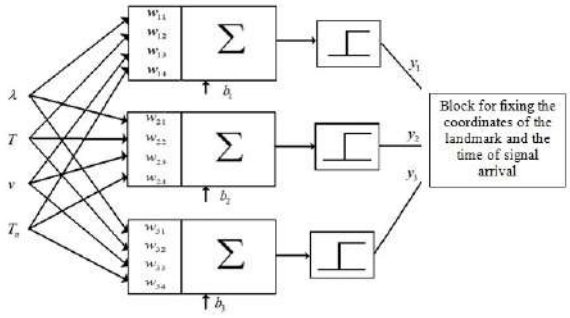

Figure 1: Neural network for wind farms.

A mathematical model, as well as its software or hardware implementation, built on the principle of the organization and functioning of biological neural networks - networks of nerve cells of a living organism. With regard to wind turbines, the neural network will work as follows. After all the experiments, data on air flows near the blade and the necessary effects on the control elements will be collected. These data are transmitted to the input and output of the neural network, respectively. In the process of training the neural network, the coefficients and the form of the model are selected, optimally linking the input and output data. After training, the coefficients are loaded into the microcontroller/microprocessor. In accordance with certain disturbances of the environment, the obtained coefficients are used to form a suitable control signal to the blade control elements (Burton, 2001, Zheng, 2014).

7 RESULTS AND DISCUSSION

Next, we need to understand the impact of various parameters such as network size and complexity on accuracy, speed, and efficiency, and how to optimize them. We also need to analyze the use of deep learning algorithms to adjust the wind turbine blade depending on environmental conditions. Here, we

need to emphasize the importance of data preprocessing and how a neural network can be used to improve the accuracy and speed of deep learning algorithms. In addition, it should be noted that deep learning can be used to automate certain tasks, such as detecting and fixing leaks or anomalies, as well as using other objects.

The feasibility study of the effectiveness of the developed methodology is based on the demonstration of comparative data on modern developments in this area. Due to the lack of the proposed technology (universal mechanization of wind turbines) and its obvious effectiveness (obvious increase in differential efficiency), and also taking into account a certain increase in efficiency (due to an increase in the efficiency of solar modules due to surface cooling), and finally, given that the technology obviously reduces the contribution to global warming, the implementation of the technology is economically justified in terms of developing the market. The methodology is large-scale, since in methodological terms it allows optimizing the components of the developed complex separately, and then optimizing the entire complex as a whole. Consequently, the developed methods can be used globally by interested scientists and engineers of friendly countries. The methods are also scalable, since in practical terms the size, speed and performance of the equipment can be increased/decreased both component by component (changing the dimensions of a separate element of mechanization or the power of the control base - for example, expanding the residents of the SCADA system), and scaling the entire complex in terms of duplicating bases, subordinate objects.

8 CONCLUSIONS

Therefore, it should be made the conclusion of the investigation. Neural networks are very powerful and can learn quickly, adapt to new situations and learn from past experiences. This is especially useful when it comes to such tasks, as neural networks can quickly learn and adapt to a new environment, producing more accurate and efficient results. In addition, neural networks can be used to automate some tasks. In this study, we consider methods and algorithms for improving or most effectively using neural networks when working with small-sized wind turbines.

ACKNOWLEDGEMENTS

Funding: The study was supported by the Russian Science Foundation grant No. 23-11-20016, https://rscf.ru/project/23-11-20016/

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