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Application of Artificial Intelligence in Mechanical Engineering

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ABSTRACT

The use of artificial intelligence (AI) is becoming more prevalent across many industries. Examples include intelligently based control, intelligently based mechanical systems, pattern recognition-based systems, and knowledge processing. Method/Statistical Analysis: In this paper, an extensive review was conducted on the applications of ANN in intelligent mechanical engineering systems, including fault diagnosis in machines, mechanical structure analysis, and geometry modelling of mechanical structures, mechanical design, and its optimization. Findings: The adaptation of artificial neural networks (ANN), particularly in the field of mechanical engineering, is still in its early stages of development. This paper highlights the different ways artificial neural networks (ANNs) are used in intelligent-based systems, as well as the potential for reducing costs and time and obtaining more efficient systems for mechanical-based design and defect detection. Application/Improvements: This work will be improved in the future by adding more AI applications to the design of mechanically based systems.

INTRODUCTION

Artificial neural networks (ANN) are being used increasingly in nearly all engineering applications, including those based in computer science, mathematics, and mechanical engineering. In an engineering application, it falls under the category of adaptive based programming system. ANN [1] is a novel information processing methodology in general. Its central tenet is based on contemporary neuroscience research that combines numerous parallel, segmental, and simulation-based methodologies in an effort to uncover the fundamental properties of information processing based on how the human brain functions [2]. Recent studies [2–8] demonstrate a significant advancement of artificial neural networks (ANN) in mechanical engineering based on intelligent structure, design, and optimization. ANN is a sophisticated computer technique that can represent the interactions between different processes and their variables. The rapid development and application of technology has led to an increase in the complexity of the overall structure of current mechanically based equipment. Additionally, it is highly automated. Today, ANN has a strong position in the field of mechanical engineering [2]. Its technology is advanced in several areas of mechanical engineering, including machine design, manufacture, and operation, among others. This study reviews the use of ANN in the field of mechanical engineering for tasks like diagnosing intelligent machine defects, analysing mechanical structure, designing mechanical systems, and optimising them. The following is the order of this review: The relationship between AI and mechanical engineering is depicted in full in Module 2 along with its architecture. Module 3 explains the Artificial Neural Network's technique. The different kinds of artificial neural networks utilised in the mechanical area are described in Module 4. The usage of ANN in the field of mechanical engineering is detailed in Module 5, including intelligent defect diagnosis, mechanical structure analysis, mechanical design and its optimization, etc. Module 6 concludes by presenting the findings of this survey.

LITERATURE REVIEW

Relationship of Mechanical Engineering and Artificial Intelligence

Mechanical engineering is regarded as a fundamental discipline in daily life due to the rapid advancement of technology. However, mechanical engineering-based technology has a number of drawbacks, such as inconsistent systems caused by malfunctioning mechanical components. The output won't be impacted because the AI can quickly swap the input and process it in a timely manner. For this fault, it can also make decisions that are effective. When the nature of the input information is more complex, the total process of translating the input into the output in mechanical engineering-based technology faces additional challenges. Compared to a manual information system, the regular information system could be more prone to errors. The need for AI-based automated processing systems increased in order to address these drawbacks. The shortcomings of mechanical engineering are simple to fix if AI and mechanical

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engineering are integrated.

Artificial Neural Network

A computational model of AI called an artificial neural network is inspired by the overall structure or functional components of a neural network (NN). These biological simulations mimic the characteristics of neurons and the electrical signals that flow between them in an idealised setting. These signals have the potential to be treated before being sent as outputs. An interconnected cluster of artificial neurons makes up a typical NN. It applies a method of calculation to the obtained signals as input. Every neuron has an output function for every distinct input. The term "excitation function" refers to it. Through the signal attached to it, the linkages that connect the two neurons convey a weighted priority. The weight is how it is described. The output of the network will also change when the NN's connection, weighting, and function modes are changed [10–11].

METHOD AND MATERIAL

ANN'S Types Used in Mechanical Engineering

The many intelligent approaches based on ANNs used in mechanical engineering for designing and mistake eradication are listed below. The other ANN-based technologies in mechanical engineering will be applied in more applications as time and research permit.

Back Propagation Neural Networks, version (BPNN)

The BPNN is a feed-forward network with multiple layers that is based on the BP algorithm [10]. The BPNN, a three-layer multi-layer network, is being employed in a variety of applications, including mechanical engineering. In the hidden layer, the nonlinear function serves as a conversion function. The BPNN algorithm is divided into two steps: The active dissemination process is the first step, and the back propagation procedure is the second.

Hopfield Neural Network, version (HNN)

It is a Hopfield recurrent NN model with a network foundation. There is a connection in this network that acts as a feedback from the output to the input. The Hopfield network often has two types of feedback, such as discrete and continuous. This network operates on a feedback basis. Therefore, the output of this network will remain constant. Based on the Hopfield's invocation, the user has the ability to change or remove the entire network's output from the input. In order to create a new output, the output can then be fed back into the input.

Self-Organizing Map (SOM) Network, Version

Combative NN of the self-organizing variety. The input layer and output layer are the two layers that are present in this network. A two-dimensional array of neurons make up the output layer. Through the neurons, the two layers are linked to one another. With the help of the nodes in the output layer, this NN's training is carried out.

RESULT AND DISCUSSION

Uses for artificial neural networks in intelligent mechanical engineering

Since neural networks have the potential to automatically learn, they have been applied in the past to the application of diagnosing defects in rotating machinery. This characteristic of the NN enables the detection of faults using training data. In addition to this capability, the NN may also be utilised to resolve difficult nonlinear problem types. The diagnosis of these issues may be more difficult. At the moment [12-14], a variety of AI-based technologies are routinely employed to identify failures in mechanical engineering. Reasoning based on rule, reasoning based on case, and tree fault-based identification are the typical AI-based fault recognition techniques. An expert-based mechanical fault identification system is built from the fundamental configuration and fundamental architecture of the conventional system based on experts. It has a case database that is manually based, a rule-based database for fault identification, a database diagnosis system for different fault types, machine knowledge-based processing for fault reasoning, an interpreter for the fault identification process, a learning system, and a system for the interface between a machine and a human.

Mechanical Fault Diagnosis Based on ANN

The process of intelligently based fault identification begins with the gathering of data linked to faults. The spectra derived from the feature's frequency must be obtained in order to extract it. These methods for extracting error features can be divided into two groups: statistical and model-based methods [15-16]. It has a number of algorithms that can handle any form of signal obtained from these machines the overall procedure is displayed. Principal component

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analysis (PCA) and Radial Basis Function Neural Networks (RBFNN), among other NNs, are used. Intelligent fault identification is often carried out by feeding inputs into neurons, which produce outputs based on signals and faults existing in the equipment. The user testing and training the approach does not need to study the entire NN while employing these NN's. To measure the mechanical technology of real-world mechanically based machines, to identify the uncommon defeat, and to speculate on the future position of the technology6, the error identification in mechanical engineering-based technology is based on the addition in the overall working of the equipment based on the information of comparative constant condition, the examination of the constant signal and then merging it with the objects dentification condition. Its major strategy is to avoid errors by using the most recent adaptations of all the technologies found in past studies linked to mechanical engineering. The presence of some mistakes and repair analysis methods make it simple to spot errors in mechanically based machinery that can be used in industries. The development of contemporary technology has led to the identification of defects or flaws in mechanical engineering-based technology, which is based on the technology management process. The key to understanding the fundamental symptom of the error as fault is fault identification. A symbolic expert system with a foundation in logic is the standard method of detecting errors. However, this system uncovers a number of flaws, including the inability to progress to a certain stage, the ANN's capacity for self-learning, the system's propensity for non-linear based mapping, its capacity for parallel processing, and its tolerance for error when developing a sophisticated error identification system. An ANN-based error identification system employs an input to perform numerical calculations to determine the condition of the defect based on its symptoms. In general, it consists of the interface between human and machine-based modules, knowledge base diagnosis and reasoning, information retrieval module, and lastly, system learning module.

ANN based Intelligent Diagnostic System for Rotating Machinery

The entire approach of fault identification of rotating machinery has advanced in the last years in the scenario of fault detection in equipment based on mechanical engineering. The achievement reached a significant economic peak in its actual use. The suggested solution uses a universally applicable neural network identification system for fan rotating machinery problem detection. The identification contains two major parts. The fan is the first, followed by the engine. The major component of this system can be further broken down into five sub-components, including vibration-based, temperature-based, noise-based, and oil-based parameters.

Reciprocating machinery intelligent diagnosis system based on ANN

One of the key characteristics of high-quality reciprocating machinery is its set of extremely fast reciprocating speeds. In contrast to rotating machinery, it has a more complex dynamics-based morphology. This characteristic makes the fault identification process increasingly dependent on NN-based systems and integrated NN-based identification mechanisms. The combination of the vibro-based acoustic (VA) signal and the oil analysis procedure creates the entire mechanism.

Mechanical Structure Based on ANN, modelling in geometry and analysis

Mechanical engineers can employ structure analysis to realise the design parameters that can be modal the mapping parameter [18]. In order to identify as well as for the mapping process, ANN-based methods have largely replaced the finite element analysis method that was previously used. The average or overall value of the training parameter is subsequently used by the structure analysis parameter of NN in various structures of the data that were obtained by finite element analysis for training the BPNN. To comprehend the modal parameters with the relationship mapping process, the processes of structure analysis and dynamic design are applied. This is how mechanical engineering structure analysis is generally done. To analyse the overall mechanism would be too complex given the solution. The training of BPNN or the structure analysis of the data are two mechanisms that are employed in finite element-based procedures. This system identifies and analyses the relationship of mapping between the two, using the input of the artificial neural network as modal parameters and the output as design parameters. The complex surface modelling, one of the categories of geometric modelling, specifically uses the spline function fitting mechanism. It may also be utilised to modify the overall structural dynamic design. This method is more sophisticated with varied boundary conditions. Changing its drawbacks is more challenging. Numerous computations and processes are required. Mechanical engineering has evolved with the usage of ANN's nonlinear mapping methodology in geometric modelling. The input and output of the calculation are the coordinates of the particle surface in X and Y, respectively. The sample set of ANN is trained using these coordinates. This is distinguishable by the modeling's curved surface.

Mechanical Design and Optimization based on ANN

Modern mechanical engineering-based systems and machineries have complex structural designs. These mechanical engineering-based systems are complex because of their static characteristics, such as stiffness, strength, and pressure, and because their dynamic characteristics, such as force, displacement, speed, acceleration, frequency, and

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vibration, are thought to be an optimization problem [2]. Calculations in mathematics provide the basis of this integrated problem. The optimization issues are divided into categories according to size, topology, and performance. Different optimization techniques built on mathematical programming are insufficient to solve these kinds of optimization problems. The Hopfield NN has the characteristic that its maximum energy tends toward stability. This characteristic allows the aforementioned forms of optimization errors to be transformed into an ANN energy function solution. The goal function's minimum point, starting from the initial state, is one of the characteristics of the dynamic ANN system. The minimal point can also make use of the ANN to finish the optimization calculation. The use of AI to solve optimization problems is illustrated in paper. In their study, the authors discussed the use of AI-based approaches for various optimization challenges [9]. This methodology is employed for problem optimization in a number of areas, including vibrating systems, composite structures, 2D and 3D structures, and acoustics. In, a coupled field-based optimization of a thermoelectricity-based problem is carried out. Considerations of bodies that experienced simultaneous thermal and mechanical field knocking are referred to be coupled fields [17-20]. The optimization and discovery of certain numerical values that fit for composite systems, which have a high strength-to-weight ratio when compared to commonly used materials, is another use of AI-based systems [21-24].

CONCLUSION

This study offers a thorough analysis of artificial intelligence's varieties and uses, as well as how it relates to mechanical engineering in terms of the process of mechanical fault detection and design. This essay includes an overview of the precise uses of artificial intelligence in mechanical engineering. There includes a thorough review of a number of applications, including error identification, diagnostic systems, mechanical structure analysis, and mechanical design. This study shows that the entire area of mechanical engineering uses a lot of AI-based intelligent technique. This article also comes to the conclusion that many other AI-based technologies can be easily integrated with the field of mechanical engineering to enhance the mechanical system. Future work will involve putting AI-based systems into practice to propose a hybrid-based intelligent design of mechanical systems for the purposes of observing, controlling, and error-identification systems based on AI-based systems like fuzzy logic and neural networks to advance the state of mechanical engineering as it stands today.

REFERENCES

1. Al-Bahrani, M., & Cree, A. (2021). In situ detection of oil leakage by new self-sensing nanocomposite sensor containing MWCNTs. *Applied Nanoscience*, *11*(9), 2433-2445.
2. Quintana, G., Garcia-Romeu, M. L., & Ciurana, J. (2011). Surface roughness monitoring application based on artificial neural networks for ball-end milling operations. *Journal of Intelligent Manufacturing*, *22*(4), 607-617.
3. Al-Abboodi, H., Fan, H., Mhmood, I. A., & Al-Bahrani, M. (2022). The dry sliding wear rate of a Fe-based amorphous coating prepared on mild steel by HVOF thermal spraying. *Journal of Materials Research and Technology*, *18*, 1682-1691.
4. Meesad, P., & Yen, G. G. (2000). Pattern classification by a neurofuzzy network: application to vibration monitoring. *ISA transactions*, *39*(3), 293-308.
5. Al-Bahrani, M. (2019). *The Manufacture and Testing of Self-Sensing CNTs Nanocomposites for Damage Detecting Applications* (Doctoral dissertation, University of Plymouth).
6. Tanaka, M., Sakawa, M., Shiromaru, I., & Matsumoto, T. (1995, October). Application of Kohonen's self-organizing network to the diagnosis system for rotating machinery. In *1995 IEEE International Conference on Systems, Man and Cybernetics. Intelligent Systems for the 21st Century* (Vol. 5, pp. 4039-4044). IEEE.
7. Al-Bahrani, M., Majdi, H. S., Abed, A. M., & Cree, A. (2022). An innovated method to monitor the health condition of the thermoelectric cooling system using nanocomposite-based CNTs. *International Journal of Energy Research*, *46*(6), 7519-7528.
8. Sivanandam, S. N., & Deepa, S. N. (2006). *Introduction to neural networks using Matlab 6.0*. Tata McGraw-Hill Education.
9. Balamurugan, R. J., AL-bonsrulah, H. A., Raja, V., Kumar, L., Kannan, S. D., Madasamy, S. K., ... & Al-Bahrani, M. (2022). Design and Multiperspectivity based performance investigations of H-Darrieus vertical Axis wind turbine through computational fluid dynamics adopted with moving reference frame approaches. *International Journal of Low-Carbon Technologies*.

Volume 2, **Number** 3, November 2022
https://doi.org/10.47709/brilliance.v2i3.1719

10. Khayyat, H. A. (2018). ANN based Intelligent Mechanical Engineering Design: A Review. *Indian J. Sci. Technol*, *11*(27), 1-7..
11. Al-Bahrani, M., Gombos, Z. J., & Cree, A. (2018). The mechanical properties of functionalised MWCNT infused epoxy resin: A theoretical and experimental study. *Int. J. Mech. Mechatronics Eng*, *18*, 76-86.
12. Burczyński, T., & Szczepanik, M. (2013). Intelligent optimal design of spatial structures. *Computers & Structures*, *127*, 102-115.
13. Madasamy, S. K., Raja, V., AL-bonsrulah, H. A., & Al-Bahrani, M. (2022). Design, development, and multi-disciplinary investigations of aerodynamic, structural, energy, and exergy factors on 1 kW horizontal Axis wind turbine. *International Journal of Low-Carbon Technologies*.
14. Landay, J. A., & Myers, B. A. (2001). Sketching interfaces: Toward more human interface design. *Computer*, *34*(3), 56-64.
15. Wu, X., Fan, H., Wang, W., Zhang, M., Al-Bahrani, M., & Ma, L. (2022). Photochemical synthesis of bimetallic CuNiS x quantum dots onto gC 3 N 4 as a cocatalyst for high hydrogen evolution. *New Journal of Chemistry*, *46*(31), 15095-15101.
16. Obaid, A. J., & Sharma, S. (2020). Recent trends and development of heuristic artificial intelligence approach in mechanical system and engineering product design. *Saudi Journal of Engineering and Technology*, *5*(2), 86-93.
17. Al-Bahrani, M., Bouaissi, A., & Cree, A. (2022). The fabrication and testing of a self-sensing MWCNT nanocomposite sensor for oil leak detection. *International Journal of Low-Carbon Technologies*, *17*, 622-629.
18. Baillie, D., & Mathew, J. (1994). Diagnosing rolling element bearing faults with artificial neural networks. *Acoustics Australia*, *22*, 79-79.
19. Abbas, E. F., Al-abady, A., Raja, V., AL-bonsrulah, H. A., & Al-Bahrani, M. (2022). Effect of air gap depth on Trombe wall system using computational fluid dynamics. *International Journal of Low-Carbon Technologies*, *17*, 941-949.
20. Wu, X., Fan, H., Wang, W., Zhang, M., Al-Bahrani, M., & Ma, L. (2022). Photochemical synthesis of bimetallic CuNiS x quantum dots onto gC 3 N 4 as a cocatalyst for high hydrogen evolution. *New Journal of Chemistry*, *46*(31), 15095-15101.
21. Al-Abboodi, H., Fan, H., Mahmood, I. A., & Al-Bahrani, M. (2021). Experimental Investigation and Numerical Simulation for Corrosion Rate of Amorphous/Nano-Crystalline Coating Influenced by Temperatures. *Nanomaterials*, *11*(12), 3298.
22. Al-Bahrani, M., Alhakeem, M. R. H., & Cree, A. (2020). Damage sensing and mechanical properties of a laminate composite material containing MWCNTs during low-velocity impact. *Journal of Petroleum Research and Studies*, *10*(4), 147-164.
23. Al-Bahrani, M., & Cree, A. (2018). Predicting the mechanical behavior of epoxy resin based carbon nanotubes.
24. Wu, X., Fan, H., Wang, W., Zhang, M., Al-Bahrani, M., & Ma, L. (2022). Photochemical synthesis of bimetallic CuNiS x quantum dots onto gC 3 N 4 as a cocatalyst for high hydrogen evolution. *New Journal of Chemistry*, *46*(31), 15095-15101.