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Integrating Artificial Neural Networks with MOORA Method for Construction Material Selection

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Abstract: *Artificial neural networks (ANNs) are designed to mimic the complex and flexible structure of the human brain, serve as powerful tools for addressing complex, nonlinear challenges in a variety of domains. This review examines the development, operation, and practical applications of ANNs, focusing on their potential to solve important problems in medical science—particularly within the realm of gastrointestinal research. While basic scientific knowledge has advanced significantly, progress in the clinical management of gastrointestinal diseases has been limited. ANNs present a promising approach because they can learn from data, detect patterns, and make predictions without requiring prior assumptions about the data distribution—providing a distinct advantage over traditional parametric methods. This review emphasizes the importance of selecting appropriate ANN architectures and optimizing their parameters to suit specific problems. However, an optimized neural network represents only the initial stage; its successful application depends on integration into comprehensive decision-support systems. Furthermore, this paper highlights the combined potential of combining ANNs with Multi-criteria decision-making approaches - particularly the multi-objective optimization by ratio analysis (MOORA) method - improve problem-solving and decision-making in complex, data-intensive systems. MOORA method enhances ANN-driven applications by providing a structured and efficient framework for evaluating multiple criteria, making them particularly valuable in areas such as material selection, project planning, and performance evaluation. Combining ANNs with other advanced computational techniques – such as fuzzy logic and evolutionary algorithms – further increases their robustness and adaptability. This study addresses common misconceptions about the capabilities of ANNs, encouraging more realistic and practical expectations regarding their implementation. By leveraging ANN properties that mimic the human brain – adaptability, fault tolerance, and the ability to manage uncertain or incomplete information – researchers and experts can build intelligent, high-performance systems. Ultimately, the study underscores the role of ANNs in improving decision-making and driving innovation in a wide range of fields, from healthcare to industrial manufacturing.*
Keywords: *Artificial Neural Networks (ANNs), Neural Network Architecture Optimization, Medical Applications of AI, Pattern Recognition and Non-Parametric Modeling, MOORA Method in Decision Support Systems*

1. INTRODUCTION

In the past, researchers have developed a number of "standard" architectures for artificial neural networks. These predefined architectures facilitate easy, fast, and Choosing the most appropriate neural network architecture for a particular type of challenge requires effective problem solving. After identifying the nature of the problem, the next important step is to select and fine-tune the appropriate model neural network topology. Both the architecture and its parameters require fine-tuning. However, having a fine-tuned neural network topology does not mean that the network is ready for use; it only represents a necessary initial step. [1] This article seeks to explore the potential benefits of using artificial neural networks (ANNs), one of the most advanced tools in artificial intelligence currently available, as an appropriate approach to address the growing challenges and demands in medical science - particularly within the field of gastroenterology. Currently, we face a paradox: despite significant advances in scientific knowledge at the basic research level, progress in the quality of clinical care provided in the routine management of gastrointestinal diseases in real-world settings has not kept pace. [2] Artificial neural networks, also known as neural networks or connectionist models, provide a powerful approach to handling complex, pattern-specific problems, including tasks related to classification and time series (trend) analysis. A key advantage of neural networks is their nonparametric nature, which allows them to build models without prior assumptions about the data distribution or possible relationships between variables - assumptions typically required by conventional parametric statistical methods. [3] Artificial neural networks are often touted as the future of computing, largely due to their self-learning capabilities that eliminate the need for traditional programming expertise. However, this has led to some misunderstandings. Exciting claims have exaggerated the capabilities of these neuron-inspired processors, claiming that they can solve almost any problem. Such exaggerations have led to disappointment among some users, who, after unsuccessful attempts to apply neural networks to their challenges, have found them to be complex and difficult to understand. [4] The human brain has an extraordinary ability to process incomplete, ambiguous, or ambiguous information and draw meaningful conclusions from it. For example, we can understand someone's handwriting even if it is very different from our own. A baby can recognize that a ball and an orange share the same circular shape. Even newborns who are only a few days old can recognize their mothers through touch, voice, and smell. We can recognize familiar faces from blurry images. The brain is an incredibly complex organ that manages and coordinates the entire functioning of the body. [5] The human brain is an incredibly complex, nonlinear, and parallel information processing system. It has the extraordinary ability to self-organize its basic components, neurons, to perform tasks such as pattern recognition, perception, and motor control at speeds far exceeding those of today's most advanced digital computers. In general, an artificial neural network (ANN) is imitate how the brain performs specific tasks or functions. ANNs are typically realized in electronic hardware or simulated in digital computers via software. [6] The study of the human brain has a history spanning thousands of years. As modern electronics developed, it became a logical step to try to replicate the brain's cognitive functions. The foundation for artificial neural networks was laid when neurophysiologist Warren McCulloch and mathematician Walter Pitts introduced a theoretical framework for describing neural activity. They created a simple neural network model using electrical circuits. Because of their remarkable ability to analyze complex and uncertain information, neural networks can often detect patterns and trends that are beyond the reach of human cognition or conventional computational techniques. [7] This research provides the foundation for the second school of thought to operate. The main tools used in building this platform include neural networks (reference sources such as IEEE Transactions on Neural Computing, Stat soft Inc., and Apron Systems Inc.) and fuzzy logic. In both human and computer systems, the central control units are the brain and the computer's central processing unit (CPU), respectively. While computers excel at performing arithmetic and logical operations with high efficiency, the human brain is particularly adept at tasks involving pattern recognition and pattern matching. [8] It provides strong global search capabilities and can learn near-optimal solutions without the need for gradient information from error functions. Evolutionary algorithms (EAs) introduce novel concepts and strategies for problem solving, improve the principles of Natural progression, improving the efficiency of population-based optimization methods. Currently, intelligent computerization is experiencing rapid progress, with key techniques including fuzzy logic, neural networks, and evolutionary algorithms. As computer technology continues to evolve, these methods have made significant progress, and they show a trend toward convergence. [9] Instead of relying on Instead of relying solely on complex rules and mathematical formulas, artificial neural networks are capable of distinguishing key patterns within complex, multidimensional datasets. They also exhibit properties such as fault tolerance, robustness, and resistance to noise. Since data from energy systems is inherently noisy, these challenges lend themselves particularly well to neural network approaches. This research paper aims to explore the various applications of neural networks in solving energy-related problems-related problems. These applications are organized thematically rather than chronologically or in any other order. [10] A nerve is a specialized biological cell that transmits information between neurons through It undergoes electrical and chemical changes and has a central structure called the soma, along with two types of branched projections: dendrites and an axon. The soma contains the nucleus, which contains genetic material, and the cytoplasm, which contains essential molecular components machinery necessary for the neuron's functions. The communication process follows a specific path - neurons receive signals from other neurons via their dendrites and transmit them accordingly. [11] One way to interpret The interpretation of these graphs is as follows: A negative partial derivative indicates that as a particular input variable increases, the corresponding output variable decreases. Conversely, a positive partial derivative indicates that the output increases with an increase in the input. The second aspect of partial derivative analysis (PDA) involves assessing the relative influence of each input on the output of the ANN. This is achieved by summing the squared values of the partial derivatives for each input variable. [12] These methods rely on precise knowledge of computer dynamics, as well as Techniques involving estimation and numerical computation are used to simulate computer behavior; however, the inherent complexity of such problems can lead to the emergence of uncertainties, leading to unrealistic or inaccurate models. As a result, practical applications often involve approximate analysis and linear assumptions. Artificial neural networks (ANNs), on the other hand, use algorithms designed to mimic certain brain-like functions, It includes the ability to learn from past experiences, draw generalizations from comparable situations, and evaluate situations previous decisions are not optimal. [13] Artificial intelligence (AI) is a branch of computer science that focuses on creating software that can perform advanced, intelligent calculations similar to those typically performed by the human brain. It includes techniques, tools, and systems designed to mimic human approaches to logical reasoning, inductive learning, and problem-solving. AI development can be classified into two primary groups. The first includes approaches and systems that emulate human expertise and make decisions based on predefined rules, as found in expert systems. [14] This study seeks to explore the principles, applications, and potential developments of artificial neural networks in the manufacturing sector, providing useful insights and resources for both academic research and real-world application. A dedicated section of the paper outlines the evolution of neural network technologies and explains the basic principles of artificial neural networks. Another section provides an in-depth review of their applications within manufacturing processes. In addition, this paper highlights the limitations associated with neural networks and proposes their integration with knowledge-based expert systems to enhance the development of intelligent manufacturing systems. [15]

2. MATERIAL AND METHOD

Cement: Cement is a fine, soft powder that acts as a binding agent, hardening when it comes into contact with water. It is made by heating a mixture of limestone and clay, which is then ground into a powder.
Mortar: Mortar is a mixture of sand and cement commonly used to build brick or retaining walls. Although its composition appears similar to concrete, there are certain differences in their formulations. These differences indicate that mortar and cement are not interchangeable in their applications.
Reinforced concrete: Reinforced concrete is essential in structures that must handle both high compressive forces and tension. It is primarily used in projects designed to withstand extreme conditions, including natural disasters such as earthquakes and hurricanes.
Thermal insulating materials: Thermal insulation materials, which are materials or combinations that resist heat flow, are commonly referred to as thermal-protective and insulating materials. Thermal protection involves preventing heat from escaping or dispersing, while thermal insulation focuses on preventing external heat from penetrating a space.
Plywood door: Plywood is capable of handling significant stress and exposure to natural environments. Structural plywood is ideal for applications such as beams and hoardings, but it is also widely used in boxes, crates, interior structures, outdoor furniture and cabinets. In addition, it serves as a reliable material for wall and roof bracing.
Density: Density refers to the amount of mass within a given volume, indicating how tightly the material is packed into an object or material. It is calculated using the formula: Density is equal to the mass of a substance divided by its volume (density = mass ÷ volume).
Specific heat: Specific heat capacity is the amount of energy required to raise the temperature of one gram of a substance by one degree Celsius. This energy is usually expressed in joules per gram/degree Celsius (J/g°C) or calories per gram/degree Celsius (call/gecko).
Thermal conductivity: Thermal conductivity (commonly denoted ask, λ, or κ) describes the inherent ability of a material to conduct or transfer Heat is also described as the amount of thermal energy that flows through a material when there is a unit temperature difference between its two surfaces, across a unit thickness, within a unit time, and over a unit area.
Thermal resistance: Thermal resistance measures the ability of a material or system to resist the flow of heat, whereas electrical resistance refers to the opposition to electric current. Thermal resistance is determined by dividing the temperature difference by the heat transfer rate and is measured in units of Kelvin/Watt (K/W).

MOORA method: When selecting the most appropriate material from a growing number of potential options with unique properties, applications, advantages, and disadvantages, designers must fully understand the functional requirements of each specific component and have a deep knowledge of the criteria appropriate for the specific engineering design. Selecting an inappropriate material can incur significant costs and ultimately This can result in premature failure or breakdown of the component or product. [16] Although there are numerous multi-objective decision-making (MODM) techniques to deal with various evaluation and selection problems, this study investigates the potential of a new MODM technique - Multi-Objective Optimization Based on Ratio Analysis (MOORA) - to optimize various grinding parameters. The MOORA method is simple and computationally efficient, enabling decision-makers to filter out less suitable options and select the most suitable alternative, thereby improving existing selection processes. [17] This paper addresses Six decision-making scenarios were analyzed, involving the selection of optimal welding parameters in various techniques such as submerged arc welding, gas tungsten arc welding, gas metal arc welding, CO_2 laser welding, and friction stir welding. In each case, the results obtained using the MOORA method closely corresponded with the findings of previous studies, highlighting the relevance, effectiveness, and flexibility of the method in addressing complex decision-making tasks within modern manufacturing systems. [18] The MOORA method has been recognized as one of the most efficient tools in decision support systems (DSS) due to its ability to reliably assess employee performance based on established criteria and assigned weights. Currently, it is widely used in various selection and decision-making situations. Its primary advantages lie in its adaptability and strong ability to distinguish between preferences. In this research, a decision support system using the MOORA method was designed to assess performance staff and teachers at Dayanara College. [19] Although the most basic type Interval fuzzy numbers are particularly valuable for solving problems in semi-structured problem systems or unstructured domains, as they require identifying minimum and maximum values - that is, interval boundaries. A recently introduced approach, the MOORA method, stands out for its efficiency and simplicity. It provides a logically structured and easy-to-follow A method used to identify the most suitable option or to prioritize among several available alternatives options. [20] It should It should be noted that only a few of the MODM applications discussed earlier are directly related to road and bridge construction. Nevertheless, the use of MODM techniques in other construction sectors is well supported. This paper aims to determine the best option for widening a two-lane highway in Thuringia, Germany, using the introduced MOORA method Brayers. This study seeks to demonstrate the practicality and effectiveness of using MODM methods in the context of road and bridge construction projects. [21] This study uses both the SAW method and the MOORA method to estimate the performance scores of teaching assistants (TAs) using data from the Teaching Assistant Ratings dataset found in the UCI Machine Learning repository. In addition, a comparison between these two techniques seeks to produce more accurate and improved computational results from experimental data. The SAW method, also known as simple additive weighting, is a decision-making technique that calculates the weighted sum of each alternative performance across relevant criteria. [22] This study uses both the SAW method and the MOORA method to estimate the performance ratings of teaching assistants (TAs) using data obtained from the Teaching Assistant Ratings dataset in the UCI Machine Learning Repository. Furthermore, the comparison between these two approaches aims to provide more accurate and refined computational results based on experimental data. The SAW method, short for Simple Additive Weighting, is a decision-making technique that aggregates the performance scores of each option on appropriate criteria and calculates a weighted total. [23] MOORA It is a recent addition to the family of multi-criteria decision-making (MCDM) methods, which use statistical techniques to determine the most appropriate choice from a variety of alternatives. Known for its simplicity, this method provides highly accurate rankings of material preferences and is user-friendly. In this context, Prowers et al. used the MOORA method to support their selection process method to rank maintenance contractors from the perspective of both customers and contractors. Similarly, Maranda and Chakravarthy used the MOORA approach to select materials by evaluating various options based on their characteristics and price. [24] The Multi-Objective Optimization by Ratio Analysis (MOORA) method, developed by Provers and Saatsakis, has been recognized for its adaptability and ease of use in distinguishing subjective elements of evaluation through the use of weighted decision criteria across multiple attributes. It is easy to understand and adaptable, allowing for effective separation of components within the evaluation process. In addition, the MOORA method demonstrates strong selectivity in dealing with conflicting objectives and criteria, effectively distinguishing between beneficial (benefit) and non-beneficial (cost) factors. [25] In today's highly competitive environment, choosing the right supplier has become a major concern for businesses. Companies prioritize factors such as product quality, cost-effectiveness, and on-time delivery. Recently, driven by growing environmental awareness among governments, individuals, and organizations, choosing green suppliers is becoming increasingly important, with companies now emphasizing whether the materials they purchase are environmentally friendly, non-toxic, and recyclable. These environmental factors have become essential criteria in evaluating and selecting suppliers. [26] This research paper is structured into several sections. One section presents a literature review This study focuses on the concepts, applications, and research gaps related to MOORA, Project Risk Management (PRM), Delphi Method, Design of Experiments (DOE), and Monte Carlo Simulation (MCS). One section describes the research methodology, followed by a discussion of the data collection strategy, while another section presents the implementation process of the selected techniques Subsequent sections include sensitivity analysis, present results, and provide a discussion of the findings in a risk management context supported by relevant scenarios. [27] Involving multiple decision makers is more effective than relying on a single individual, as it helps reduce bias and minimize bias Informed part of the decision-making process. This research provides an intelligent ranking of prospective solar power plant sites by using the fuzzy MOORA method. Identifying the optimal location for a solar power plant is a complex multi-criterion decision-making (MCDM) challenge involving quantitative and qualitative factors. Evaluating the characteristics of various areas is a difficult task, which was successfully solved with the input of experts in electrical, environmental, and industrial engineering. [28] The basic idea of the MOORA reference point approach is to initially normalize the raw data and then apply appropriate weighting factors. Using these weighted normalized values, an optimal score is established for each criterion or objective by identifying the maximum achievable value. For benefit-type criteria, the optimal reference point corresponds to the highest performance value, whereas for cost-type criteria, it is represented by the lowest performance value. [29] Forced cooling has an adverse effect on the single-scan laser bending process, resulting in a smaller bending angle compared to conditions with natural cooling. At low line power levels, the decrease in bending angle is more significant when using high laser power than when using low laser power. In addition, it is noteworthy that under high line power and low laser power conditions, forced cooling is beneficial in achieving a higher bending angle. Therefore, it can be concluded that forced cooling is more suitable when operating with high line power and low laser power, as this combination will produce an increased bending angle. [30]

3. RESULTS AND DISCUSSION

TABLE. 1 Artificial neural networks

	Density	Specific heat	Thermal conductivity	Thermal resistance
Cement	12.00	456.00	23.00	257.00
Mortar	23.00	789.00	92.00	421.00
Reinforced concrete	45.00	236.00	83.00	835.00
Thermal insulating materials	98.00	903.00	24.00	953.00
Plywood door	67.00	742.00	62.00	975.00

Table 1 shows data analyzed using artificial neural networks and the MOORA method, evaluating five building materials in terms of density, specific heat, thermal conductivity, and thermal resistance. Plywood doors and thermal insulation materials demonstrate the greatest thermal resistance (975.00 and 953.00), making them the most effective in reducing heat flow. Cement has the lowest values for both density and thermal conductivity, while reinforced concrete stands out for its high density but offers only moderate thermal resistance. Mortar exhibits a uniform profile, especially with high thermal conductivity. These differences emphasize the suitability of each material in terms of thermal performance and structural requirements.

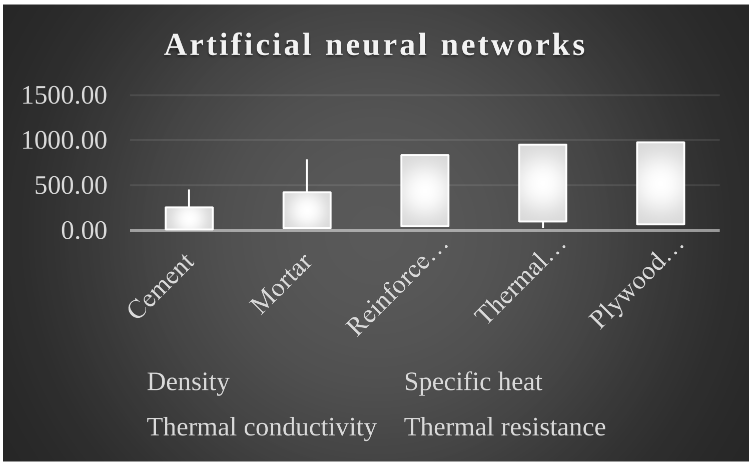

FIGURE: 1 Artificial neural networks

Figure 1 uses artificial neural networks and the MOORA method to compare materials according to essential thermal properties. Thermal insulation materials and plywood doors exhibit the greatest thermal resistance, making them the most suitable for insulation purposes. Reinforced concrete offers a combination of high density and significant resistance, whereas cement and mortar have low thermal resistance and show different levels of thermal conductivity.

TABLE. 2 Normalized data

	Normalized Data			
	Density	Specific heat	Thermal conductivity	Thermal resistance
Cement	0.0926	0.3039	0.1614	0.1536
Mortar	0.1775	0.5258	0.6457	0.2516
Reinforced concrete	0.3473	0.1573	0.5825	0.4991
Thermal insulating materials	0.7563	0.6017	0.1684	0.5696
Plywood door	0.5171	0.4944	0.4351	0.5827

Table 2 presents the normalized data obtained by the MOORA method, which allows a consistent comparison of materials in terms of density, specific heat, thermal conductivity and thermal resistance. Plywood doors and thermal insulation materials show the highest normalized thermal resistance values (0.5827 and 0.5696), highlighting their effective insulation properties. Cement records the lowest values in most categories, indicating weak thermal performance. Reinforced concrete shows moderate results, especially in density (0.3473) and thermal resistance (0.4991). Mortar performs reasonably well, especially in thermal conductivity (0.6457). Normalization facilitates the assessment of the thermal performance and overall application suitability of each material.

TABLE. 3 Weight

	Weight			
Cement	0.55	0.55	0.55	0.55
Mortar	0.55	0.55	0.55	0.55
Reinforced concrete	0.55	0.55	0.55	0.55
Thermal insulating materials	0.55	0.55	0.55	0.55
Plywood door	0.55	0.55	0.55	0.55

Table 3 outlines the weighting values assigned to each material and property by the MOORA method. Each material – cement, mortar, reinforced concrete, thermal insulation materials and plywood doors – receives the same weight of 0.55 for all four factors: density, specific heat, thermal conductivity and thermal resistance. This equal weighting reflects that each criterion has the same level of importance in the assessment. By using fixed weights, the analysis avoids bias, ensuring that the comparison relies only on normalized data. This approach supports fair and objective assessments of Thermal properties of materials and their suitability for different construction applications.

TABLE. 4 Weighted normalized decision matrix

	Weighted normalized decision matrix			
Cement	0.0509	0.1671	0.0888	0.0845
Mortar	0.0976	0.2892	0.3551	0.1384
Reinforced concrete	0.1910	0.0865	0.3204	0.2745
Thermal insulating materials	0.4160	0.3309	0.0926	0.3133
Plywood door	0.2844	0.2719	0.2393	0.3205

Table 4 shows the weighted and normalized result matrix that is generated MOORA method, where the normalized data are combined with equal weights (0.55) to evaluate the performance of each material. Plywood doors and thermal insulation materials achieve the highest weighted values in thermal resistance (0.3205 and 0.3133), which confirms their performance as insulating materials. Reinforced concrete records significant scores in both density (0.1910) and thermal resistance (0.2745), which shows a balance between structural strength and thermal performance. Mortar shows the highest value in thermal conductivity (0.3551), which reflects increased heat transfer. Cement records the lowest values overall. These results guide material selection based on thermal and structural requirements.

TABLE. 5 Assessment value

	Assessment value
Cement	0.0448
Mortar	-0.1067
Reinforced concrete	-0.3174
Thermal insulating materials	0.3410
Plywood door	-0.0035

Table 5 Presents and reflects the final assessment values obtained through the MOORA method overall performance of each material based on weighted and normalized data. Thermal insulation materials received the highest scores with a positive value of 0.3410, which highlights their excellent thermal efficiency. Cement also achieved a positive score (0.0448), indicating moderate performance. On the other hand, mortar (-0.1067), reinforced concrete (-0.3174), and plywood doors (-0.0035) had negative values, indicating that they are less suitable for increasing thermal efficiency in this context. These results help in selecting the most suitable materials for applications that focus on thermal resistance and energy conservation.

TABLE. 6 Rank

	Rank
Cement	2
Mortar	4
Reinforced concrete	5
Thermal insulating materials	1
Plywood door	3

Table 6 Provides a final ranking of the items based on the evaluation scores obtained by MOORA method. Thermal insulation materials take first place, highlighting their excellent thermal efficiency and overall performance. Cement is in second place, indicating a moderate fit, while plywood doors come in third, showing consistent but slightly lower performance. Due to their relatively low scores, mortar and reinforced concrete are ranked fourth and fifth, respectively, reflecting poor thermal performance. This ranking supports informed material selection by identifying the most efficient choices for thermal insulation and meeting structural requirements in various construction applications.

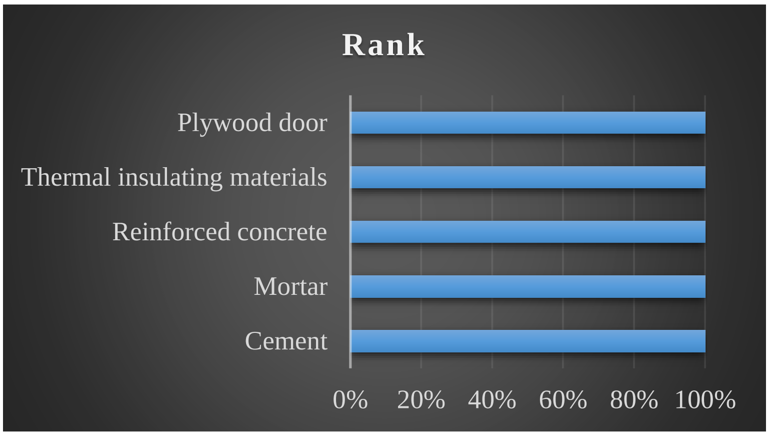

FIGURE: 2 Rank

Figure 2 depicts the material ranking based on the MOORA method. Thermal insulation materials lead with the highest performance (rank 1), while cement and plywood doors are in second and third place, respectively. Mortar ranks fourth and reinforced concrete ranks fifth, reflecting their relatively low thermal performance.

4. CONCLUSION

In short, artificial neural networks (ANNs) offer a revolutionary approach to solving complex, nonlinear challenges in a variety of fields, with promising applications in areas such as the gastrointestinal tract and energy systems. While numerous “standard” ANN architectures have been developed to simplify and speed up the problem-solving process, identifying and optimizing the neural network topology that is best suited for a particular task is an essential initial step. ANNs are different from traditional parametric models in that they can learn and model complex relationships without requiring prior assumptions about the data distribution, making them highly useful for tasks such as pattern recognition, classification, and predictive analysis. This flexibility has facilitated their application in a wide range of domains, from medical diagnostics to industrial processes. Although widely considered a key component of the future of computing due to their ability to learn autonomously, ANNs are sometimes misunderstood. Inflated expectations have led to disappointment when users encounter problems with implementation and training and fail to achieve the desired results. It is important to recognize that while ANNs are powerful tools, they require a solid understanding of their architecture, proper training techniques, and rigorous validation to operate effectively. One of their greatest strengths is their ability to handle incomplete, noisy, or ambiguous data, which is common in real-world settings such as medical environments. This makes ANNs particularly valuable in medical science, where data variability and complexity often challenge conventional analytical methods. Furthermore, advances in decision-making Techniques such as the MOORA (Multi-Objective Optimization by Ratio Analysis) method enhance the utility of artificial neural networks (ANNs) by providing a systematic and efficient framework systematic and efficient means of evaluating and prioritizing alternatives across multiple criteria. MOORA’s straightforward yet effective distinction between benefit and cost factors makes it particularly valuable in areas such as material selection, project planning, and performance evaluation. For example, in construction, it helps engineers objectively evaluate and select materials that meet thermal and structural performance requirements. As the field of intelligent computing advances, the integration of neural networks with other computational techniques, such as fuzzy logic and evolutionary algorithms, is becoming increasingly widespread, resulting in more powerful and adaptive problem-solving tools. In line with the human brain’s ability to process complex data quickly and effectively, ANNs continue to expand the boundaries of artificial intelligence. Their combination with decision-support systems such as MOORA enhances their practical value, empowering researchers and professionals to make evidence-based decisions based on robust data analysis. With a realistic understanding of their capabilities and careful application, ANNs are poised to make significant progress in a variety of industries.

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