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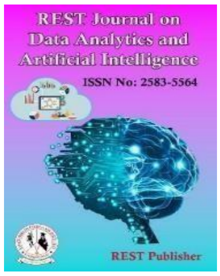

Integration of Grab Methods with Artificial Neural Networks for Enhanced Decision-Making Systems

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Abstract: *This study explores the architecture, development, and practical applications of artificial neural networks (ANNs), with advances in Gray Relational Analysis (GRA) techniques. ANNs are computational models designed to model biological neural systems, consisting of layers of interconnected neurons—i.e., input, hidden, and output layers—connected by synaptic weights. Operating through a connectionist approach, these networks effectively mimic the four basic functions of biological neurons: receiving input, integrating information, processing data, and generating output. Traditional ANNs, although powerful, face limitations in embedded systems due to their reliance on high-precision digital information transfer and the resulting resource demands. This has prompted the development of more efficient alternatives, such as spiking neural networks (SNNs), which use event-driven spiking signals to reduce power consumption and memory usage. The field has advanced further by incorporating theoretical models for quantum neural computing and the use of genetic algorithms employing various crossovers and mutation techniques. The versatility of ANNs is evident in a variety of applications. In healthcare, they aid in pattern recognition associated with conditions such as breast cancer and diabetes. For water resource management, ANN models predict relationships between rainfall and water levels. In financial sectors, they analyze complex economic conditions and assess credit risk for small business loans. Industrial applications include modelling complex systems in manufacturing plants, although widespread adoption in this field is limited. Complementing neural network advances, GRA methods have emerged to address multi-criteria decision-making challenges. Notable advances include the GRAS techniques have been developed to correct matrices with negative values, while fuzzy GRA methods now include interval-valued triangular fuzzy numbers and probabilistically uncertain linguistic word sets. Recent advances include innovations such as score values and normalized Hamming distances within single-valued neutrosophic fuzzy stein summary, these computational approaches offer powerful ways to solve complex, multidimensional problems, with recent studies highlighting improved performance and promising prospects for future application.*

***Keywords**:* Artificial Neural Networks (ANNs), Gray Relational Analysis (GRA), spiking Neural Networks (SNNs), Multi-Criteria Decision Making (MCDM), Pattern Recognition.

1. INTRODUTION

Artificial neural networks (ANNs) are computational structures composed of connected neurons arranged in input, hidden, and output layers. These neurons communicate through synaptic weights. ANNs are very useful, and are commonly used in areas such as pattern recognition, forecasting, and regression analysis. [1] Artificial neural networks (ANNs) offer a useful solution to many challenges in designing energy systems. These models are inspired by the brain's complex cognitive and emotional processes, helping to interpret and manipulate information through techniques such as pattern recognition and data manipulation. [2] It mimics the human nervous system by using a network of interconnected artificial neurons, processing data within a connectionist framework. [3] However, the performance of traditional ANNs often relies on high-precision digital information transfer, which requires significant power and memory resources. As a result, they are not practical for use in embedded systems with limited power and storage capacity. Unlike conventional ANNs, spiking neural networks (SNNs) use event-driven spiking signals, making them more power and memory-efficient for use in embedded platforms. [4] The use of quantum theoretical methods in ANNs for cognitive modelling has also been proposed although these suggestions are largely theoretical, emphasizing the potential benefits of quantum neural computing. Christly introduced the concept of quantum learning, discussing the practical challenges in implementing the approach. However, he did not evaluate its performance through simulation. [5] The artificial neural network (ANN) method for generating reservoir injection series presented in this paper differs from traditional synthetic hydrology approaches by using data-driven analysis instead of model-based methods. In contrast, conventional time series modelling often uses multivariate autoregressive moving average (ARMA) models. [6] A neural network is made up of many neurons interconnected by a network of connections. The configuration of the network changes depending on the types of neurons involved and how they are interconnected. [7] This research aims to implement a neural network approach to assessing small business loans, specifically targeting the credit risk assessment of publicly listed companies. It adopts an empirical method, using two different neural network architectures trained on real data. [8] Undoubtedly, Sophocles had no idea what artificial neural networks would become when he wrote, two thousand years later, “Many things cause horror and wonder, but none more terrible and wonderful than man.” However, this quote from *Antigun* aptly captures the early fascination and interest surrounding the development of these computational tools. [9] Neurons serve as the basic units of the human brain, helping us use past experiences to guide our actions. Artificial neural networks (ANNs) are computational algorithms designed to mimic the four main functions of biological neurons: receiving input from other neurons or sources, integrating the inputs, processing the combined data, and generating output. [10] ANN models are very useful tools for predicting the relationship between rainfall and water level parameters. Their results help in making informed decisions for water resources planning and management. In addition, they help urban planners and managers to take appropriate measures to address unfavourable forecasts. [11] Although activation functions such as the sigmoid (Equation 5) and the hyperbolic tangent (Equation 6) are theoretically similar in their properties, ability to approximate any continuous function, they tend to exhibit distinct behaviours in real-world applications. [12] Genetic algorithms rely on two primary drivers: crossover and mutation. In addition to the traditional random crossover and mutation, many alternative methods have been introduced. Crossover techniques include two-point, multi-point, arithmetic, and heuristic crossover. For mutation, common approaches include boundary mutation, uniform mutation, and random mutation. [13] Artificial neural networks (ANNs) were proposed almost a decade ago to model the behaviour of complex systems in industrial plants. Although they have been widely adopted in the financial and business sectors for analyzing and forecasting complex economic conditions, most published studies on industrial plant modelling are limited in scope, and ANN-based modelling has yet to gain widespread acceptance within the industry. [14] This approach to variable selection is particularly attractive when the fit of the data is uncertain, especially in the case of nonlinearities in financial markets. In this study, predictive models were developed to predict future excess return levels for an S&P 500 stock portfolio. A follow-up experiment aimed at the same goal was conducted using a different methodology. [15]

2. MATERIAL AND METHODS

Alternatives:

Breast cancer: Breast cancer is characterized by the uncontrolled growth of abnormal cells in breast tissue, which can lead to tumour growth and the potential to spread to other parts of the body. Early detection through regular checkups and self-examinations is essential to improve survival rates and enhance the effectiveness of treatment.

Diabetes: This is a chronic condition that occurs when the pancreas fails to produce enough insulin or when the body cannot use insulin effectively. Insulin is a hormone that controls blood sugar levels.

Liver disorders: Liver disorders include a variety of conditions that disrupt the normal functions of the liver. They can be caused by factors such as viral infections, heavy alcohol consumption, hereditary conditions, and autoimmune diseases. Common liver problems include hepatitis, fatty liver disease, cirrhosis, and liver cancer.

Object: In grammar, an object is a noun or pronoun that receives the action of a verb or is attached to a preposition. Simply put, it refers to the person or thing that the object acts on or does something.

Recognition: To recognize someone or something is to recognize them because you have seen or encountered them before. For example: I recognized my former high school teacher in the photo. Medical professionals are taught to recognize the symptoms of various diseases.

Evolution parameter:

Sigmoid function (LS): The sigmoid function is a mathematical formula that maps any real-valued number to the range between 0 and 1. It is often used as an activation function in neural networks, where low input values yield outputs close to 0 and high inputs yield outputs close to 1.

Hip. Tan. Function (HT): In mathematics, hyperbolic functions are similar to traditional trigonometric functions, but they are based on a hyperbola instead of a circle. Just as coordinates (cost, send) locate a unit circle, points (cost, send) locate the right side of a unit hyperbola.

Sinusoid function (SN): A sinusoidal function is characterized by a smooth and repeating wave-like shape. The term "sinusoidal" is derived from the sine function, which describes this type of oscillation. Common real-life examples that can be modelled by sinusoidal functions include an oscillating pendulum, a spring, or the vibration of a guitar string.

Gaussian function (GS): Gaussian functions, which take the form of logarithmic expressions, produce a concave, bell-shaped curve resembling a quadratic profile. These functions are often described in terms of their full width at half maximum (FWHM), denoted by w. Another important parameter, c, represents the distance from the centre point b to the inflection points of the curve, which lie at x = b ± c.

GRA methods: The primary advantage of the GRAS method lies in its ability to provide an analytical solution in a single iteration, which eliminates the need for powerful nonlinear solvers (such as GAMS) to obtain GRAS results are affected by this restriction. However, the analytical method and methodology introduced by Julius and Oosterhaven (2003) rely on the assumption that each row and column in a symmetric matrix has at least one positive entry. [16] The GRA model relies on the similarity of fluctuation patterns between data series. Which is estimated by the area between their zigzag curves? As a result, the general GRA model is built from a holistic perspective. Furthermore, the formulas clearly show that the absolute, relative, and synthetic measurements in gray relational analysis all exhibit symmetrical properties. [17] This research introduces an improved fuzzy gray relational analysis (GRA) method aimed at solving multi-criteria decision-making (MCDM) problems, in which the criteria are expressed through linguistic terms represented by interval-valued triangular fuzzy numbers, and the criterion weights are not initially specified. To establish these weights, an optimization model is developed, drawing on the key concepts of conventional GRA. [18] This study presents a solution to overcome the ranking inconsistency problem in GRA-based network selection algorithms. To reduce the impact of ranking fluctuations, a thorough analysis of the GRA-based method is conducted to identify the root causes of this problem. [19] Julius and Oosterhaven (hereinafter J&O) introduce a modified version of the RAS matrix balancing technique, called GRAS, which provides a reliable and theoretically robust approach to correcting matrices with negative values that match specific row and column totals. Their formulation of the GRAS method was based on the principle of minimum information, a concept further explored by Oosterhaven. [20] The primary contribution of this study is its method for determining attribute weights by incorporating both given spherical linguistic fuzzy information and completely unknown weight data within the framework of the traditional GRA approach. [21] The remainder of this paper is organized as follows: Section 2 reviews the relevant literature. Section 3 describes the development of an evaluation index system using the Delphi method. Section 4 presents a new model framework based on Gray Relational Analysis (GRA) that incorporates subjective and objective weighting techniques. [22] The remainder of this paper is organized as follows: Section 2 reviews the relevant literature. Section 3 describes the development of an evaluation index system using the Delphi method. Section 4 presents a new model framework based on Gray Relational Analysis (GRA) that incorporates subjective and objective weighting techniques. [23] The GRA method is improved by integrating probabilistic uncertain linguistic term sets (PULTSs) with initially unknown attribute weights. The CRITIC technique is used to objectively determine these weights through the scoring function of the PULTSs. A new probabilistic uncertain linguistic GRA (PUL-GRA) method is proposed to address multi-attribute group decision making (MAGDM) problems within probabilistic uncertain linguistic frameworks. To verify the effectiveness of this method, a case study is carried out on the selection of locations for electric vehicle charging stations (EVCS). In addition, comparative analyses are conducted with the PULWA operator, ULWA operator, and PUL-TOPSIS method to confirm the reliability and validity of the PUL-GRA approach. [24] Welding quality, especially in terms of bead geometry and mechanical strength, is greatly influenced by both material properties and process parameters. Consequently, identifying optimal processing conditions to improve welding performance is of great importance. [25] Chapter four improves the Gray Relational Analysis (GRA) method for multi-attribute decision making (MADM) by incorporating score value, precision value, certainty value, and normalized Hamming distance within the framework of single-valued neutrosopic hazy table fuzzy sets (SVNHFS). Furthermore, it defines the positive ideal solution (PIS) and negative ideal solution (NIS) based on the score and precision values. [26] The high-dimensional structure of equation (3) makes it computationally infeasible to solve for (x) q(x) using finite-element-type approaches. However, since the transition paths are typically concentrated in a narrow, half-dimensional reaction tube, the relevant area is significantly smaller than the entire domain Ω. By improving this approximation, the finite temperature string method was developed [6, 18] to simultaneously identify the optimal reaction tube and the associated committer function. [27] . Weather forecasts play a key role for utility companies in estimating energy demand for the coming days. On a daily basis, individuals rely on weather forecasts to make decisions such as appropriate clothing choices. Since severe weather conditions – such as heavy rain, snow, and wind chill – can significantly disrupt outdoor activities, accurate forecasts are essential for planning and preparedness. To improve weather forecasting performance and overcome these challenges, we present a weather forecasting model that uses artificial neural networks. [28] The widespread adoption of artificial neural networks (ANNs) can be attributed to their potential as versatile nonlinear predictive models. For a long time, forecasting has relied primarily on linear statistical methods. While these linear models are valued for their simplicity and ease of interpretation, they often struggle to capture the nonlinear patterns present in complex real-world data. [29] Artificial neural networks (ANNs) are computational architectures designed to model mathematical systems that are designed to simulate. to mimic the structure and function of the mammalian brain, unlike traditional computer systems. Neural networks, also known as convolutional systems, parallel distributed systems, or adaptive systems, are composed of a large number of interconnected processing units that operate simultaneously in parallel.

3. RESULT AND DISCUSSION

TABLE 1. Artificial Neural Network

	Sigmoid function (LS)	Hip. Tan. function (HT)	Sinusoid function (SN)	Gaussian function (GS)
Breast cancer	33.00	55.00	22.00	66.00
Diabetic	59.00	99.00	76.00	65.00
Liver disorders	78.00	63.00	87.00	62.09
Object	73.00	79.00	69.00	90.00
Recognition	45.00	61.00	53.00	69.00

Table 1 demonstrates how artificial neural networks interact with each other using the Gray Relational Analysis (GRA) method. This approach evaluates the performance and correlation between multiple criteria, which enables the neural network to process and adapt to complex data patterns. GRA improves decision-making by measuring the relationships between variables within the ANN framework.

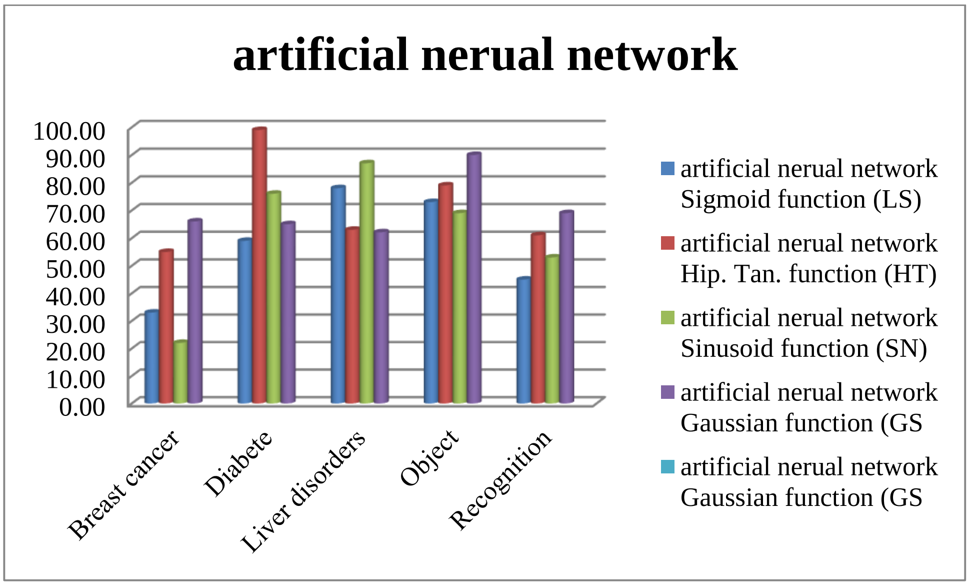

FIGURE 1. artifial neural network

Figure 1 illustrates how artificial neural networks interact with each other using the Gray Relational Analysis (GRA) method. This integration allows the network to effectively analyze, compare, and rank input variables. By measuring the relationships between data points, GRA improves the ANN's ability to make accurate decisions and adapt to changing environments.

TABLE 2. performance value

	Sigmoid function (LS)	Hip. Tan. function (HT)	Sinusoid function (SN)	Gaussian function (GS
Breast cancer	0.42308	0.55556	1.00000	0.94076
Diabetic	0.75641	1.00000	0.28947	0.95523
Liver disorders	1.00000	0.63636	0.25287	1.00000
Object	0.93590	0.79798	0.31884	0.68989
Recognition	0.57692	0.61616	0.41509	0.89986

Table 2 It presents performance values derived from the Gray Relational Analysis (GRA) method, which explains how various parameters interact within the system. The GRA method measures the relationships between variables, allowing for useful comparison and evaluation. This interplay supports improved decision-making and performance evaluation in complex data environments.

TABLE 3. Weight

Breast cancer	35.00	35.00	35.00	35.00
Diabetic	35.00	35.00	35.00	35.00
Liver disorders	35.00	35.00	35.00	35.00
Object	35.00	35.00	35.00	35.00
Recognition	35.00	35.00	35.00	35.00

Table 3 shows the weights calculated using the Gray Relational Analysis (GRA) method, illustrating how different factors affect outcomes. These weights reflect the relative importance of each criterion, enabling more accurate estimates. The interoperability of weighted parameters supports robust decision-making and improves analytical accuracy within the system.

TABLE 4. Weighted normalized decision matrix

Breast cancer	0.00000	1.00000	0.11796
Diabetes	1.00000	0.00000	0.20128
Liver disorders	0.00000	0.00000	1.00000
Object	0.00037	0.00000	0.00000
Recognition	0.00000	0.00000	0.02489

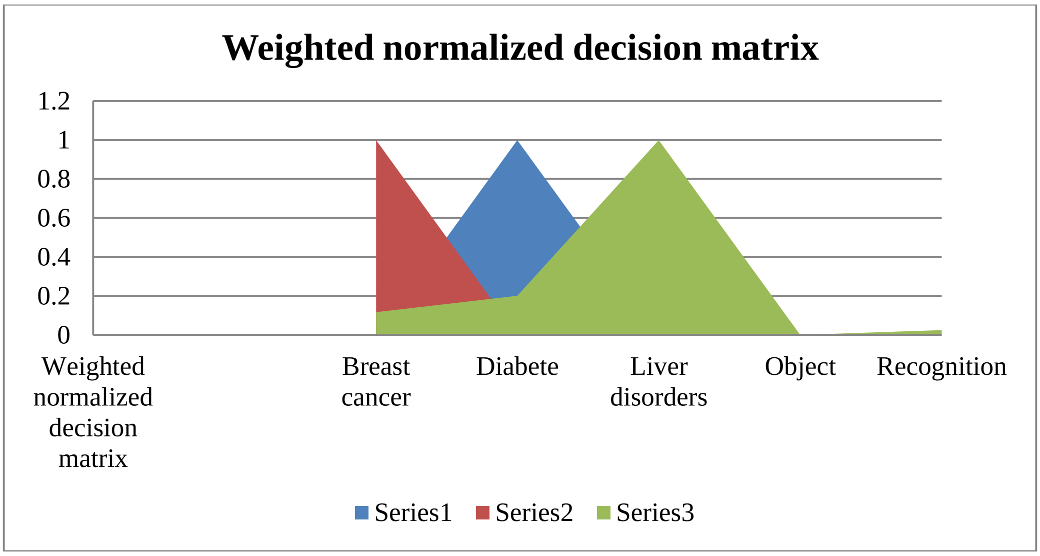

FIGURE 2. Weighted normalized decision matrix

Figure 2 It generates a weighted and normalized decision matrix through the Gray Relational Analysis (GRA) method. which demonstrates how the criteria interact within a balanced framework. This matrix combines both weights and normalized values, enabling fair comparisons. This interoperability improves the system's ability to evaluate alternatives and support informed data-driven decisions.

TABLE 5. preference score & rank

	Preference Score	**Rank**
Breast cancer	0.00000	**1**
Diabetic	0.00000	**2**
Liver disorders	0.00000	**5**
Object	0.00000	**4**
Recognition	0.00000	**3**

Table 5 presents the option scores and rankings obtained using the Gray Relational Analysis (GRA) method, which shows how different alternatives interact with each other within the decision-making process. By calculating and comparing the scores, the GRA method enables a clear ranking of the options. This interoperability ensures objective evaluation and supports the selection of the optimal solution's

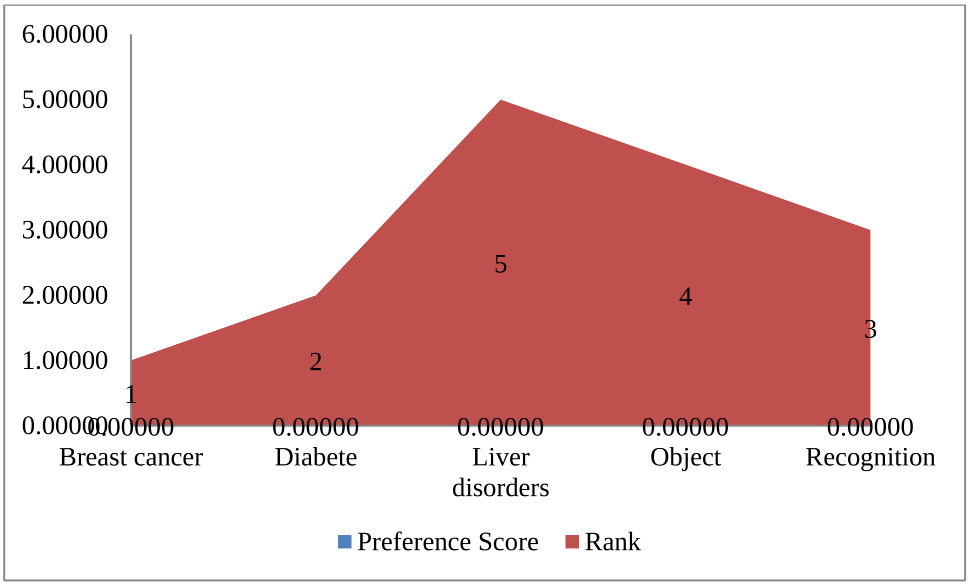

FIGURE 3. preference score & rank

Figure 3 illustrates the preference scores and rankings obtained through the Gray Relational Analysis (GRA) method, showing how alternatives perform in the evaluation process. The visual representation highlights the comparative performance, facilitating clear interpretation. This functionality improves decision-making by providing an organized, data-driven view of ranked outcomes.

4. CONCLUSION

Artificial neural networks (ANNs), which model the structure and functions of the human nervous system, have shown exceptional performance as computational models. Using multiple layers of interconnected neurons connected by synaptic weights, ANNs are particularly strong in tasks such as pattern recognition, prediction, regression, and simulation of complex systems in various fields. Their developments have been marked by a series of innovations aimed at addressing inherent limitations. Traditional ANNs, despite their efficiency, often require considerable power and memory due to their reliance on high-precision digital communications. This has driven the emergence of more efficient alternatives, particularly spiking neural networks (SNNs) that use event-based spiking signals to optimize power and memory usage—which are well suited for resource-constrained embedded systems. In addition to these advances, neural computing has also seen research efforts incorporating quantum theoretical approaches, although many remain at the conceptual stage. Hybrid techniques such as combining ANNs with genetic algorithms – enhancing functions such as crossover and mutation – have further expanded their potential applications. ANNs are now widely used in many fields: in water resources management, they help predict rainfall-water level relationships, supporting urban planning; in finance, they analyze and forecast complex economic trends; and in healthcare, they identify diagnostic patterns in diseases such as breast cancer, diabetes, and liver conditions. Gray relational analysis (GRA) is a significant complementary development that has contributed significantly to data processing and decision-support systems. Over time, GRA has evolved through variants such as GRAS – capable of handling matrices with negative values – and fuzzy GRA methods designed for multi-criteria decision-making. Recent developments include models that use probabilistic uncertain linguistic word sets and neutrosophic fuzzy fuzzy sets, which extend the applicability of GRA to more complex real-world problems. The convergence of these diverse computational strategies offers exciting opportunities for continued research and innovation. As computational resources expand and algorithms grow more sophisticated, the performance, accuracy, and applicability of neural networks and related methods are poised to improve. Ultimately, ANNs and advanced analytical frameworks, such as GRA, are reshaping the approach to information processing, prediction, and problem solving in a variety of fields. The continued development of artificial neural networks will help close the gap between artificial and biological intelligence, bringing to life the vision of human intelligence once predicted by Sophocles, who famously said, "There is nothing more terrible and more wonderful than man."

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