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VIKOR-Based Evaluation of Artificial Neural Network Integration Options: A Multi-Criteria Analysis

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Abstract: *This paper explores the integration of artificial neural networks (ANNs) with ontology-based knowledge bases to address complex challenges across various domains. The convergence of machine learning approaches with semantic data representation enables improved monitoring, understanding, and interpretation of intelligent systems that process big data. We examine how integrated approaches facilitate semantic data description processed by ANNs, including the specification of input and output data, and the representation of ANN properties and states. Our research demonstrates the effectiveness of these integrated systems in diverse applications, including electricity demand estimation, solar radiation prediction, location-based services, deep drawing process optimization, and financial market forecasting. Additionally, we analyse the implementation of The VIKOR method is a multi-criteria decision-making approach, for evaluating alternatives when faced with conflicting criteria. The combination of VIKOR with other techniques such as AHP and fuzzy approaches provides enhanced decision support capabilities. This Combining neural networks with knowledge-based systems provides substantial benefits in terms of performance, flexibility, and interpretability, addressing the limitations of isolated AI development. Our findings contribute to advancing robust AI systems that can effectively handle complex real-world problems while maintaining interpretability.*

Keywords: *Artificial Neural Networks, Integration Analysis, Performance Evaluation, Social Media Feeds, Sustainability, Sensor Networks, Flexibility Assessment, Compromise Ranking.*

1. INTRODUCTION

Currently, there is a widespread consensus that the various fields of artificial intelligence should not be developed in isolation. By adopting an integrated approach, we can not only address specific challenges but also work towards ambitious goals such as building robust AI systems. The rise of machine learning-based problem-solving approaches is driven by advances in modern theoretical models of artificial neural networks and high-performance hardware for implementing them. The various architectures, techniques, trends, and applications of neural networks continue to evolve and expand. The complexity of modern intelligent systems that process big data using artificial neural network models necessitates methods for monitoring, understanding, and interpreting their algorithms to improve performance and facilitate interpretation. Thus, the development of integration approaches for artificial neural networks and ontology-based knowledge bases is increasingly becoming practical. These integrated systems enable semantic data description processed by the ANN, including the specification and structural representation of input and output data, as well as the nature of the application problems that the ANN can solve. In addition, they facilitate the representation of the properties and states of the ANN, improving the understanding of its operation [1]. As the demand for electricity increases, demand-side estimation has become necessary. Estimating electrical energy demand using economic indicators is possible using various mathematical models, which can it can be either linear or nonlinear. Taking into account variations in economic indicators, nonlinear equations often provide more accurate demand estimates. The nonlinear relationship between economic indicators and energy demand has motivated the exploration of alternative solution approaches, including genetic algorithms. These algorithms serve as powerful optimization and random search techniques with broad applications. Genetic algorithms (GA) resemble natural evolution, where a species adapts to its environment. Similarly, a number of designs are generated and evolve within a specific design environment. Originally described by Goldberg, these algorithms are primarily used to solve optimization problems. Their main advantage is that they use accumulated Data about a previously unknown search space to direct future searches towards the most efficient solutions [2]. Renewable energy sources offer clear advantages from technical, environmental and political perspectives, making them a key component of future energy solutions. As the oldest energy source, solar energy serves as a foundation for both fossil fuels and renewable alternatives. Being freely available, it can significantly reduce the Dependence on hydrocarbon-based energy via passive and active systems. Precise solar radiation measurement tools are essential for the efficient

design of solar energy systems. Accurate estimation of solar energy is crucial in areas where solar power is planned. Although solar measurement tools enable this estimation, they may not be accessible in remote or rural areas, especially in locations suitable for solar installations. In such cases, predictive tools such as solar models provide a useful approach to reliable solar energy estimation. Artificial neural networks have demonstrated their effectiveness in estimation by predicting variables from input parameters that are not directly related. Studies by Asadeh et al., Yalcinos and Eminoclu, and Azar and McDonald provide examples of such applications. Climatic and meteorological factors play an important role in determining the solar radiation level in a given area. Therefore, artificial neural networks are very useful in analysing meteorological influences and accurately predicting solar radiation [3]. The combination Technologies related to location, data management, and communication led to the rapid expansion of the location-based services (LBS) market revolves around a crucial technology that leverages location data for filtering relevant information, enable Enhanced services like location-aware billing, targeted advertising, and personalized location-based searches add significant value. Given the importance of location information, there is a strong market demand for advanced Vehicle navigation and guidance systems offer more than just location tracking; they also provide route assistance and location-based services. Modern navigation systems rely primarily on GPS to determine vehicle position. GPS can provide accurate location data for an infinite number of users worldwide. However, it requires an unobstructed A direct view of a minimum of four satellites to function effectively. As a result, in urban environments, signal obstruction and attenuation can reduce performance, reducing overall positioning accuracy [4]. Deep drawing involves a highly intricate deformation process influenced by multiple operational parameters, such as Die shape, blank holder pressure, material characteristics, and friction conditions. This study focuses on modelling and optimizing the deep drawing process for stainless steel 304 (SUS304). To accomplish this, the key input parameters include Die curvature, punch curvature, blank holder pressure, and friction parameters. Thinning is a primary failure mode in deeply drawn parts and serves as a key process output parameter. Using the finite element (FE) analysis results, an artificial neural network (ANN) is developed to establish a relationship between the output characteristics and the critical process parameters. A feed forward back propagation ANN is trained and tested using input-output data pairs derived from FE analysis. To validate the accuracy of the FE model, its results are evaluated against results from multiple experimental tests [5]. The modern Enterprise network architecture faces various challenges during digital transformation. As a key and complex part of IT infrastructure, computer networks have shifted from traditional hardware-centric operations to business and application-centric designs. This shift represents a fundamental objective in the evolution of enterprise networks. Key barriers include limited Agility in network architecture, lack of automation and intelligence in network operations, and challenges in fault localization. These issues contribute to difficulties in meeting Service Level Agreement requirements for business continuity result in high network operational costs. To overcome these challenges, this paper presents the design of an intelligent operator that analyses network data, detects faults, and executes corrective actions. It innovative approach improves network resiliency, automates Addresses the needs of increasing digital transformation in operations, and enterprise networks [6]. The human brain is a very complex biological organ, and much is unknown about its functions. Many countries have launched large-scale projects and collaborations in brain science. These revolutionary efforts are expected to significantly improve our Enhance knowledge of brain function and contribute to treatments for neurological disorders. In addition, these efforts aim to develop machines that mimic human cognitive abilities in a variety of applications, leveraging xeromorphic computing to support the growing demand for artificial intelligence. Another area of BNN research is the creation of artificial neural networks (ANNs) that replicate the biological, structural, and functional characteristics of BNNs. These models, designed to be simplified and controllable, help validate new theories about brain function based on BNN data and facilitate drug testing for brain-related diseases. In addition, ANNs serve as brain-inspired computing platforms, enabling high-performance artificial intelligence [7]. The use of Numerical techniques for predicting financial markets and making investment decisions is becoming increasingly essential in business practices. Time series forecasting plays a key role in this field by analysing historical observations of a single variable to create a model that represents the underlying data generation process. The model is subsequently utilized for future predictions. This method is especially beneficial when the data generation process is not well understood or no appropriate explanatory model exists to connect the forecast variable with influencing factors. Multiple methods exist for time series forecasting, the most widely used being The Autoregressive Integrated Moving Average model, which is a effectively used For predicting trends in social, economic, engineering, foreign exchange, and stock markets. Its widespread use stems from its Strong statistical characteristics and the widely recognized Box-Jenkins approach employed in model development [8]. Artificial neural networks (ANNs) are highly accurate and widely utilized predictive models, with applications spanning Social, financial, technological, currency exchange, and equity markets market predictions. Their unique properties make them highly valuable for predictive tasks. Unlike traditional model-based approaches, ANNs are data-driven and self-adaptive -adapting, requiring minimal prior assumptions about the underlying models of the problems being analysed. After being trained on a given dataset (sample), ANNs can often accurately predict unseen data, even when the model is noisy. In addition, ANNs act as universal function approximation tools, capable of approximating any continuous function to a desired level of accuracy. Finally, ANNs are inherently nonlinear, unlike traditional time series forecasting methods such as Box-Jenkins or ARIMA, which assume linear data generation processes. This makes ANNs particularly useful when the underlying system exhibits nonlinear behaviour [9]. Despite advances, designing integrated photonic components and circuits remains a significant challenge. The complexity of current design workflows is driven by computational limitations and the need for highly experienced researchers. Unlike electronic

circuits, photonic integrated circuits require resource-intensive simulations to precisely forecast optical response functions. Consequently, the design process for integrated photonic devices often takes longer than the time required for their fabrication and testing. To overcome this challenge, we propose and experimentally verify a novel design approach for integrated photonics, leveraging conventional artificial neural networks (ANNs) to meet the unique requirements of photonic circuit designers. Although earlier research has explored the use of ANNs for designing individual Nan photonic devices, machine learning models that generate knowledge for devices directly compatible with integrated photonic circuits remain largely unexplored. The models and devices presented in this work are readily integral into real-world photonic circuits, offering several advantages for photonic circuit design [10]. Knowledge-based systems are widely used in medical diagnostics, offering the advantage of providing explanations for diagnoses. This is particularly important in the medical field, where validation of diagnoses is essential. However, a major challenge in building these systems is acquiring domain knowledge. Several problems arise in this process. It is difficult to transform explicit and implicit expert knowledge, which often involves personal experience, into a structured form for a knowledge base. In addition, knowledge can be inconsistent or incomplete. Another limitation is that knowledge-based systems cannot learn from experience or handle cases that are not explicitly defined within their knowledge base. Artificial neural networks process knowledge in a sub-symbolic form, making them very useful for solving nonlinear problems and approximating complex relationships within data. They can handle incomplete and imprecise data, while learning in a massively parallel and self-organizing manner. Unsupervised learning networks, such as Kohonan's self-organizing feature map, analyse high-dimensional data by mapping it onto lower-dimensional topologies while preserving its structure and distribution. However, large neural networks require analytical tools for interpretation. To reveal the structure of detailed two-dimensional Kohonan maps, we developed the U-matrix method, a visualization technique that creates a three-dimensional landscape, where valleys represent related data points and walls distinguish subcategories [11]. A traditional cellular automata (CA) model comprises a collection of uniform elements known as cells, each occupying a unique state at a regular time step. Each cell takes a state selected from a finite set. The model progresses through discrete time steps, with all cells updating their states simultaneously based on a uniform a transition mechanism where a cell's new state is determined by its prior state and the states of its neighbouring cells surrounding neighbours. Urban Cellular Automata (Urban-CA) is a specialized form of cellular automata developed to model and forecast land use and landscape transformations in urban areas. Through years of research, Urban-CA models have evolved far beyond the basic CA framework, incorporating greater complexity. Factors such as integration with environmental patterns, transformation rules, and Socio-economic frameworks have advanced Urban-CA into a refined and powerful computational tools [12]. The fast-paced progress of deep learning, fuelled by its achievements in areas such as facial recognition and gaming, has led to increased interest in developing specialized hardware accelerators for these algorithms. These accelerators are designed for two primary applications: deployment in data centres or operation On mobile devices at the network edge, where power efficiency is crucial in both cases but even more so for mobile applications due to limited battery life. Several strategies have been employed to enhance power efficiency in these accelerators, such as minimizing off-chip DRAM access, optimizing data flow between processing elements, and implementing in-memory computing (IMC) by integrating analogy data processing within digital memory arrays [13]. Heavy industrial processes are becoming increasingly automated as advances in technology such as computing power, software systems, and measurement tools align with growing market demands for quality and precise dimensional control. Steel hot rolling is a prime example, where significant advances in both online control systems and offline predictive tools have helped mills meet tighter market tolerances. The entire process has been further optimized to enhance dimensional precision and improve operational flexibility. In In hot rolling, the product's thickness is mainly regulated by accurately sensing the forces involved in the process. The mill housing and rolls behave like springs when subjected to applied loads, causing elastic deformation. This deformation must be accurately calculated to achieve the desired final the gauge of the plate or strip. Cox and mocking, together with String and Mocking, developed an empirical model describing the macroscopic plastic behaviour of metals that describes plastic flow under various continuum deformation models and thermal Strain hardening. Recently, the integration of artificial intelligence methods, including artificial neural networks (ANNs), has facilitated the creation of alternative modelling approaches [14]. Modularity refers to the ability of a system to be divided into relatively independent, replicable, and compostable subsystems or modules. Although adding modularity can introduce additional complexity into system design and development, it is often preferable to a monolithic system with a tightly integrated architecture. Each subsystem, or module, addresses a unique sub-problem that can be managed independently of the others. This approach improves collaboration, enables parallel development, and integrates diverse expertise into the design process. By ensuring that each module is loosely coupled and dedicated to a specific task, fault tolerance is improved. In addition, a modular design with well-defined interfaces makes it easier to scale and add new features without affecting existing functionality or requiring a complete system redesign. Furthermore, since each module corresponds to a specific function, error detection and troubleshooting become more efficient [15]. A fundamental a key area of neuroscience is modelling neural systems, which serves to evaluate hypotheses generated from both direct observations of biological neural tissue and artificial intelligence studies. The feasibility of modelling depends on the numerical integration of mathematical frameworks, often using differential equations in computer simulations. However, this process is often limited by computational power. As a result, most simulations run significantly slower than real-time biological processes. When modelling complex processes such as Learning or growth, which already requires minutes to days in a laboratory setting, these limitations can significantly affect the feasibility. Furthermore, the probabilistic nature of neural coding frequently

necessitates multiple simulation iterations, including parameter searches. This paper introduces a new approach to modelling large neural networks. Using A continuous-time analogy model designed using VLSI technology, this approach allows the simulation of neural systems with billions of synapses while attaining an average speed up of 10^4 [16]. Electricity systems are undergoing significant changes, driven not only by advances Not only in generation and storage technologies but also in power electronics, sensing, control, computing, and communication systems. In particular, they are evolving into highly adaptive infrastructures known as smart grids, which include Decentralized generation, smart electronic devices (IEDs), flexible AC transmission system (FACTS) components, HVDC connections, wide-area synchronized measurements, demand response, micro grids, and virtual power plants. A fundamental feature of modern smart grids is the integration of renewable energy sources. Kuwait's Electricity consumption is projected to rise substantially in the near future, making it necessary to reassess the national electricity infrastructure and explore renewable energy integration to ensure environmental sustainability [17].

2. MATERIALS AND METHOD

2.1 Parameters

Artificial:

"Artificial" refers to something that is created by humans rather than occurring naturally. It typically involves the use of tools, technology, or techniques to mimic natural processes, materials, or features. These creations are often designed with a specific purpose, such as convenience, improvement, or innovation. Examples include artificial intelligence, synthetic materials, and artificial lighting. Artificial objects or systems may resemble their natural counterparts, but their appearance and purpose often distinguish them. The term can also refer to a lack of authenticity or naturalness, often implying an element of artificiality or artifice.

Simulation Environments:

Simulation environments are virtual platforms designed to replicate real-world systems, processes, or events. They allow users to test, analyse, and experiment with various scenarios without the risks of real-world use. These environments are widely used in fields such as engineering, education, healthcare, and entertainment, providing a controlled space to simulate complex situations. By imitating real-life conditions, simulations allow users to observe outcomes, make decisions, and explore different possibilities. Examples include flight simulators for pilot training, medical simulations for surgery, and virtual laboratories for scientific experimentation. Simulation environments are essential for improving the safety, performance, and understanding of complex systems.

Sensor Networks:

Sensor networks consist of interconnected devices or sensors that collect and transmit data about their environment. These networks are intended to monitor various physical or environmental factors, including temperature, humidity, pressure, motion, or light. The data collected by these sensors is sent to a central system or server for analysis and decision-making. Sensor networks find applications in fields such as environmental monitoring, smart homes, industrial automation, and healthcare. By providing real-time data, they improve efficiency, safety, and decision-making in many sectors, enabling improved management and response to changing conditions.

Satellite Images:

Satellite imagery consists of photographs or data collected Captured by Earth-orbiting satellites, these images offer an overhead perspective of the planet's surface, capturing details such as landforms, weather patterns, and man-made structures. It is used in fields such as Ecosystem tracking, farming, city development, and catastrophe management. By providing important insights into geographic changes, climate conditions, and land use, satellite imagery helps researchers, governments, and businesses make informed decisions. The images are captured using a variety of sensors, including optical, infrared, and radar, each providing specialized data suited to different applications.

Social Media Feeds:

Social media feeds are dynamic streams of content uploaded by users to platforms such as Facebook, Twitter, Integra, and LinkedIn. These feeds display a variety of content types, such as text, images, videos, and links, and are often updated in real time. Users can engage with posts in a variety of ways by liking, commenting, sharing, or reacting. Designed to maintain user engagement, social media feeds deliver personalized and relevant content based on individual interests, interactions, and activities. They play a key role in influencing public opinion, facilitating communication, and promoting businesses, making them valuable tools for both individuals and organizations.

Performance:

Performance refers to the completion or execution of a task, activity, or role. It assesses how well someone or something performs in a given context, often measured by efficiency, effectiveness, and quality. For individuals, performance can be related to work, leisure, or creative pursuits, reflecting their ability to achieve goals or meet expectations. For machines, systems, or software, performance is typically related to speed, reliability, and efficiency. In business, performance is often measured in terms of results such as profitability or productivity. Overall, performance serves as an important measure of success or identifies areas that need improvement.

Flexibility:
Flexibility is the ability to adapt or respond to changing circumstances or environments. It is an important characteristic that helps individuals, organizations, or systems effectively manage new challenges, opportunities, and disruptions. For individuals, flexibility involves adjusting plans, adopting new perspectives, or acquiring new skills as needed. For organizations, it refers to changing strategies, operations, or structures to adapt to changing market conditions. Physically, flexibility refers to the movement extent of muscles and joints. In general, flexibility is essential for growth, resilience, and effective problem-solving in ever-changing situations.

Sustainability:
Sustainability refers to the ability to sustain processes, practices, or systems sustainably over time without depleting resources or damaging the environment. It includes economic, social, and environmental dimensions, striving to fulfil present needs without jeopardizing future generations' ability to do the same. Environmentally, sustainability involves responsible resource use, minimizing waste, and minimizing environmental impact. In business, it includes practices such as ethical sourcing, reducing carbon footprints, and fostering social responsibility. Ultimately, sustainability promotes a resilient, just, and environmentally sustainable future for all.

Challenges:
Challenges refer to difficulties, obstacles, or problems that require effort, skill, or perseverance to overcome. They can occur in many areas of life, such as personal development, education, work, or relationships. Overcoming challenges often involves confronting new situations, adjusting to change, or solving complex problems. While challenges can be stressful or threatening, they also provide opportunities for growth, learning, and improvement. Overcoming challenges builds resilience, improves problem-solving skills, and increases confidence. Whether small or significant, challenges are essential to life, motivating individuals or organizations to innovate, persevere, and pursue success.

2.2 VIKOR Method

The literature review indicates that existing multi-criteria decision-making methods are very efficient in overseeing and making decisions across multiple areas domains. This study aims to assess and choose appropriate systems for organic fertilizer manufacturing. Considering the complexity of the process, many factors need to be fully considered. Therefore, the main influencing criteria for selecting and establishing an organic fertilizer production unit were analysed using two widely used and effective MCDM models: AHP and VIKOR. In general, the VIKOR method's results align with those Of the AHP method, recognizing vermicomposting as the optimal choice for disposing, recycling, and converting organic waste. Experts primarily favour this method due to the high Final product quality, reduced processing time, and improved control over environmental parameters [18]. The key values of the characteristic indices play a key role in the final recognition decision. Although The AHP method is commonly employed to establish factor weights, it has a limitation: when dealing with a large number of factors or extensive calculations, the decision matrix may become inconsistent, disrupting the weight order relationships. This problem becomes more pronounced as the number of factors increases. To address this, Guo proposed the G1 method, an objective weighting approach that eliminates the need for consistency testing. To reduce the impact of subjective elements on target identification, especially in systems with multiple targets, this study proposes a novel multi-sensor data fusion approach combining the VIKOR and G1 methods. The challenge of multi-sensor target recognition encompasses numerous distinctive features indices, which makes it a multi-attribute decision-making challenge. To tackle this, a novel target recognition approach is proposed that Integrates the VIKOR approach with the G1 technique. The G1 method, a subjective weighting technique, offers advantages over AHP by simplifying the calculations by using the prior knowledge of the decision makers and eliminating the need for consistency testing on the judgment matrix. An application an example is presented to demonstrate and validate the effectiveness of the proposed method. In addition, this method is highly flexible and can be utilized in other MADM scenarios, such as robot selection, project evaluation, and emergency management [19]. We have chosen the VIKOR technique among MCDM methods due to its unique advantages, as it reduces individual dissatisfaction while increasing team utility. Many researchers are improving MCDM methods by integrating multiple techniques for improved outcomes. VIKOR follows this trend, and numerous studies combine it with other approaches and technologies beyond its individual applications. Of these, the most commonly used is the composite fuzzy approach. Fuzzy moment theory, developed by Lotfi Zadeh in 1965, addresses the ambiguity and uncertainty inherent in problem solving. When analysing energy power plants, data often exhibit uncertainty, making it challenging to determine exact values. For example, the annual electricity production of solar, wind, and hydroelectric power is greatly affected by seasonal conditions. By using fuzzy moment theory, it is possible to define a precise range instead of assigning a fixed value. Therefore, integrating the fuzzy approach into VIKOR Enhances the precision and dependability of the results of our study. Kaya and Kahraman used AHP and VIKOR techniques to determine the most suitable renewable energy source for Istanbul and the optimal plant location under an uncertain environment. They established the criterion weights using the AHP method and used VIKOR for the rest of the analysis [20]. In some cases, it is challenging to define a clear estimation of the decision maker's preference function. Consequently, it is beneficial for the decision maker to select solutions. To achieve this, a method is used to identify a collection of optimal solutions identified through the posterior preference expression approach. This paper presents a posterior approach utilizing Taguchi's signal-to-noise (S/N) ratios to streamline expression by integrating Combines systematic and random deviations from the target into a unified criterion. Ultimately, the VIKOR method is applied to identify the best compromise

solution that minimizes variations in the relative response deviations [21]. The use of multi-criteria Decision-making techniques have enabled a more precise and thorough analysis of companies' financial activities. The fuzzy AHP (FAHP) method was employed to identify key indicators of financial performance, whereas the VIKOR method was applied to select the optimal choice, in this case, the company with the best performance based on the given criteria. Unlike some approaches, where certain financial ratios may mask weaknesses in financial statements, this method emphasizes key ratios that are important for assessing financial performance. Given the dynamic nature of today's environment, the VIKOR and FAHP methods are widely used, which necessitates the constant adaptation of Modern decision-making techniques have evolved from traditional financial models, incorporating advanced analytics and data-driven approaches managers, who often have limited time for daily decision-making, benefit from integrating these methods into a unified decision-making framework, which enables timely and effective responses. Widely used decision-making methods, such as AHP and VIKOR, offer the flexibility to be tailored These methods are tailored to meet the requirements of decision-makers and model developers broad applications and should not be rigidly constrained by predefined assumptions, but should continue to evolve to incorporate new techniques and adapt quickly to changing environments. Beyond these multi-criteria approaches, other closely related methods can also be used, including the use of A financial model, or any framework developed to support decision-makers, can incorporate fuzzy sets for handling uncertainty and imprecise data, should accurately capture the complexity and dynamism of the business environment, ensuring the most accurate and relevant insights [22]. This procedure involves the transfer of bone fragments into the mandibular defect, maintaining the natural curvature of the mandible and preserving chewing functions. Bone fragments and blood vessels from the patient's bone fragment are transferred to the mandible, and the transplanted vessels are connected to those in the neck. Compared to artificial bone grafting, autologous bone grafting provides faster integration and promote earlier new bone formation. The main objective of this surgery is to ensure a stable and accurate reconstruction of the mandible while restoring the patient's structural integrity, aesthetics and function. Preoperative planning for mandibular reconstruction surgery involves determining the osteotomy technique, the number of fibre segments, and their precise placement in the mandible, this planning process is generally more intricate than artificial bone formation, as it involves using the patient's own fibre segments. Traditionally, preoperative planning has depended on two-dimensional radiographs or CT/MRI image slices [23]. This research combines the intuitive hyper soft set method using the VIKOR method for multi-criteria decision-making to evaluate various hydrogen production technologies. This framework highlights the strengths and limitations of different methods from both technical and sustainability perspectives. Through a comprehensive analysis, a hierarchical ranking of the evaluated techniques was established, which helps decision-makers select optimal solutions based on factors such as performance, environmental impact, and economic feasibility. This study improves hydrogen production strategies, helping stakeholders align their decisions with sustainability objectives and emerging technological advances. This study aims to identify the most suitable hydrogen production method from the various available options. By promoting environmentally friendly techniques, it paves the way for a sustainable and ecologically balanced future. Integrating the VIKOR method with an intuitive hyper soft set approach provides a comprehensive understanding of the complex interactions between various criteria and production methods. This analysis provides stakeholders with valuable insights into the strengths and limitations of each approach, facilitating well-informed decision-making [24]. Selecting a material for a specific application, especially in electroplating, is a complex task because it requires balancing many conflicting factors, including technical, environmental, and economic considerations. The VIKOR method has demonstrated significant effectiveness in material selection, especially in situations with a large number of variables. This study demonstrates the use of VIKOR, which uses a multi-criteria ranking index derived from the concept of proximity to the optimal solution, for selecting electroplating metals. By integrating VIKOR with AHP to assign weights to different criteria, decision makers can systematically evaluate attributes based on their relative importance and preferences [25]. This study aims to resolve inconsistencies in the KIP scholarship process by implementing a decision support system that improves verification and decision-making. The system supports decision-makers by providing institutional data and a structured decision model. The study uses AHP and VIKOR methods to refine the recipient selection process. The AHP method was selected for its effectiveness in handling decision-making based on multiple criteria and in developing a structured hierarchical model, while the VIKOR approach was used to reduce the limitations of AHP and identify the most suitable alternative. These methods were selected for their unique advantages in generating optimal recommendations for selecting KIP scholarship recipients at UNS. VIKOR Is an MCDM (multi-criteria decision-making) approach developed to assess and rank alternatives considering multiple criteria. It focuses on selecting and prioritizing alternatives to determine a compromise solution despite conflicting factors. Developed to improve decision-making in complex systems with multiple answers, VIKOR identifies the most appropriate option by ranking alternatives based on their proximity to an optimal solution. This approach helps Authorities like the Department of Student Affairs make well-informed decisions that align with specific needs and preferences [26]. This paper proposes the VIKOR method with DPLTS to improve the accuracy and fairness of TIP risk assessment. As one of the widely used solution methods, VIKOR aims to determine a balanced compromise that is nearest to the optimal solution. The PL VIKOR method introduced by Hang and Jing integrates PTLS to refine the decision-making process. However, the conventional PL VIKOR method focuses solely on the relationship between each alternative and the optimistic ideal, overlooking its connection with the negative ideal solution (NIS). This study aims to improve the existing PL VIKOR approach by addressing these gaps and proposing an enhanced DPL VIKOR method under probabilistic linguistic uncertainty. This revised approach considers the relationship between each alternative and

the least favourable solution, strengthens the DPL VIKOR method by integrating the NIS factor. Furthermore, this paper applies probabilistic linguistic knowledge to TIP risk assessment using the improved DPL VIKOR approach. To improve the accuracy and comprehensiveness of solving MCGDM problems in a probabilistic linguistic setting, we propose an improved DPL VIKOR method. This approach includes the relationship between each alternative and it's the positive ideal solution (PIS) and its connection to the negative ideal solution (NIS). By addressing this limitation, the improved method overcomes the limitations of the conventional PL VIKOR method, which only considers the relationship between the alternatives and the PIS and ignores their relationship with the NIS [27]. The efficiency and performance of airport operations significantly influence airport operational efficiency. In order to gain a clear understanding of operational efficiency, accurately reflect the level of quality management, and enhance market competitiveness, it is crucial for stakeholders to effectively evaluate airport operational and productivity. Parker (1997) used a fuzzy evaluation method to conduct a comparative study of nine major airports in East and Southeast Asia. Although research from domestic and international experts mainly focuses on operational efficiency, there are few studies on productivity. This study analyses the monthly operations of Hangzhou Xiaoshan International Airport in 2018 as a case study. An airport operational productivity index system is developed, and the entropy weight-VIKOR method is applied for evaluation airport operational and productivity. These findings are significant for improving airport quality management and improving market competitiveness [28]. Evidence is collected on the chemical and physical properties necessary for the effective treatment, processing, regulation, storage, or disposal of waste as approved. Each state in the United States operates its own treatment facilities, which maintain records of the safe and efficient handling of hazardous waste. Although management appears generally effective, the findings of this study indicate that significant progress is still needed in hazardous waste Regulation. To evaluate the condition of hazardous waste in different states, key variables such as Factors such as waste generation, receipt, management, external shipment, storage transfer, population density, and facility count are taken into account. To ensure the success of the final result, the author used the VIKOR method, a widely used approach in multi-criteria analysis. In short, VIKOR stands for Multi-Objective Optimization and compromise solutions. This research seeks to analyse hazardous waste management practices in the United States with the highest-ranking state in terms of hazardous waste management. In doing so, it provides insights into how well-managed states implement hazardous waste management measures to prevent pollution and protect Human health at its origin. Additionally, the study will examine hazardous waste levels, population density, and facility numbers in each state [29]. VIKOR, or compromise ranking method, provides a practical solution that closely approximates the optimal choice, where compromise is an agreement made through mutual concessions. The VIKOR MCDM approach used in this study was used to evaluate and select third-party logistics (3PL) providers for the mobile phone manufacturing sector. Among the 20 outsourcing service providers interested in handling reverse logistics operations for the industry, 11 were quickly dismissed by company management during the initial evaluation [30].

3. ANALYSIS AND DISCUSSION

TABLE 1. Determination of best and worst value of Integration of artificial neural networks using VIKOR method

	Performance	Flexibility	Sustainability	Challenges
Artificial	121	40	81	87
Simulation Environments	103	50	91	67
Sensor Networks	144	75	75	90
Satellite Images	156	60	63	20
Social Media Feeds	12	10	41	30
Best	12	30	91	20
Worst	156	10	41	90

Table 1 presents the optimal and least favourable values for integrating artificial neural networks using The VIKOR approach. The effectiveness of different factors such as flexibility, stability and challenges is analysed. Among the options, social media feeds score the lowest in performance (12) and stability (30), while satellite imagery scores the highest in performance (156) and the lowest in flexibility (10). The best values across the factors are recorded as 12 for performance, 30 for flexibility, 91 for stability and 20 for challenges. Conversely, the worst values include 156 for performance, 10 for flexibility, 41 for stability and 90 for challenges.

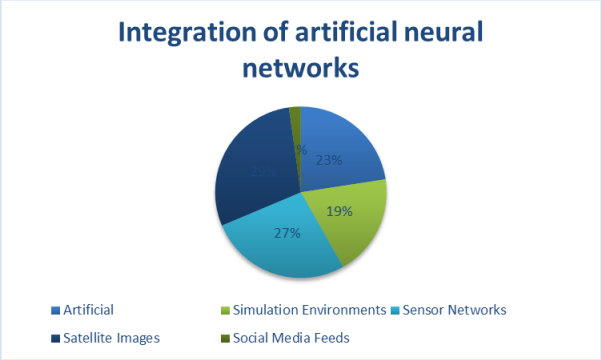

FIGURE 1. Determining the best and worst value Integration of artificial neural networks

Figure 1 illustrates the best and worst values for integrating artificial neural networks using the VIKOR method. It compares factors such as performance, flexibility, stability, and challenges across different options. The best values are 12 for performance, 30 for flexibility, 91 for stability, and 20 for challenges, while the worst values are 156, 10, 41, and 90, respectively.

TABLE 2. Calculation Sj and Rj

	Performance	Flexibility	Sustainability	Challenges	Sj	Rj
Artificial	0.189236	-0.125	0.05	0.239286	0.353522	0.239286
Simulation Environments	0.157986	-0.25	0	0.167857	0.075843	0.167857
Sensor Networks	0.229167	-0.5625	0.08	0.25	-0.00333	0.25
Satellite Images	0.25	-0.375	0.14	0	0.015	0.25
Social Media Feeds	0	0.25	0.25	0.035714	0.535714	0.25

Table 2 presents the calculation of Sj and Rj values using the VIKOR method on various factors such as efficiency, flexibility, stability and challenges. The Sj and Rj values indicate the degree of closeness to the best solution. For example, the Sj value of the artificial option is 0.353522 and the Rj value is 0.239286, while the Sj value for the sensor networks is -0.00333, with an Rj value of 0.25. These values reflect the performance of each option, with lower Sj and Rj values indicating better alignment with the best solution for each factor.

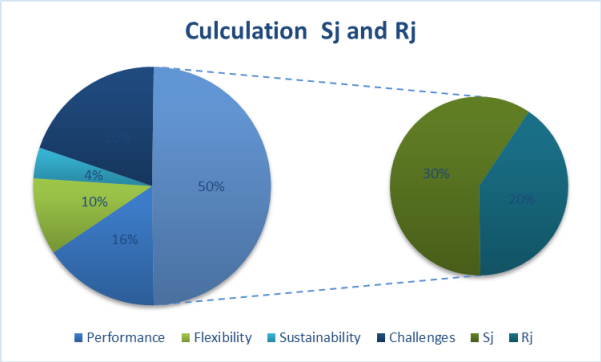

FIGURE 2. Calculation Sj, Rj

Figure 2 illustrates the calculation of Sj and Rj values, using VIKOR method for various factors including efficiency, flexibility, stability, and challenges. Each row shows the values for different options, with Sj indicating the distance to the best solution, and Rj indicating the relative closeness to the best solution. For example, in the synthetic option, the Sj and RJ values are 0.353522 and 0.239286, respectively, while the sensor networks show a Sj A value of -0.00333 and an Rj value of 0.25, signifying proximity to the best solution. These calculations help To evaluate the overall effectiveness of each alternative.

TABLE 3. Final Result of Calculation Qj

	Sj	Rj	Qj	Rank
Artificial	0.832093	0.353522	0.75236	2
Simulation Environments	0.411558	0.167857	0.129218	4
Sensor Networks	0.496667	0.25	0.315908	3
Satellite Images	0.265	0.25	0.11165	5
Social Media Feeds	0.821429	0.535714	0.990597	1

Table 3 shows the final calculation of Qj values using the VIKOR method, along with Sj, Rj, and the corresponding rankings. The Qj value combines both Sj and Rj to provide an overall ranking of the options. Social media feeds have the highest Qj value (0.990597), ranking first, while satellite imagery has the lowest Qj value (0.11165), and ranking fifth. The artificial option ranks second with a Qj value of 0.75236, while sensor networks and simulation environments rank third and fourth, respectively, with Qj values of 0.315908 and 0.129218. These results reflect the final assessment of the performance of the options.

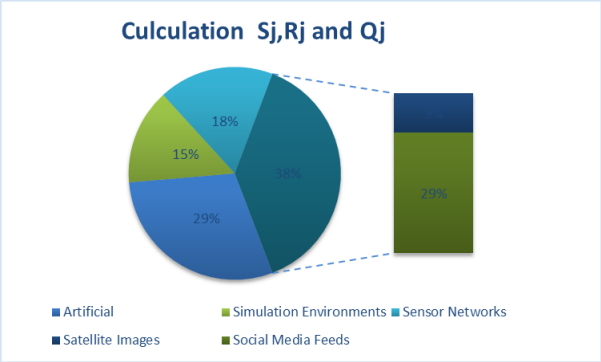

FIGURE 3. Calculation Sj, Rj and Qj

Figure 3 presents the calculation of Sj, Rj and Qj values using the VIKOR method. The Qj values are obtained from the combination of Sj and Rj, which indicates the overall performance of each option. Social media feeds have the highest Qj (0.990597), while satellite images have the lowest Qj (0.11165), reflecting their respective rankings.

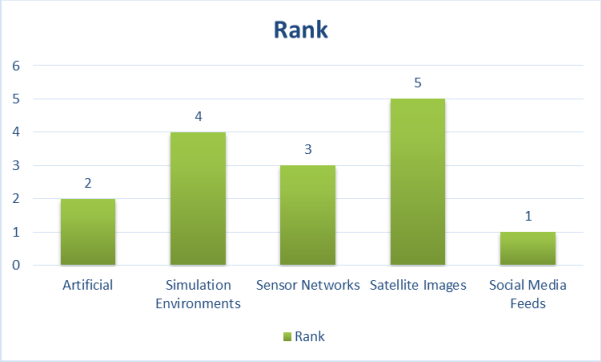

FIGURE 4. Rank

Figure 4 shows the rankings based on the VIKOR method. Social media feeds are ranked first, followed by satellites in second place, sensor networks in third place, simulation environments in fourth place, and satellite imagery in fifth place. These rankings are determined by the calculated Qj values, which reflect the overall performance of each option.

4. CONCLUSION

The VIKOR The multi-criteria decision-making method has been demonstrated as an effective strategy for evaluating integration options for artificial neural networks across multiple domains. Through careful analysis of performance, flexibility, sustainability, and challenge factors, this study has revealed significant insights into optimal integration pathways. The findings indicate that social media feeds ranked first in the overall assessment, suggesting they provide the most balanced compromise solution when considering all evaluation criteria. This is particularly noteworthy given that social media feeds scored lowest in performance and flexibility individually, yet their combined attributes created the highest Qj value (0.990597), indicating superior integrated performance. Artificial neural networks ranked second (Qj = 0.75236), demonstrating their robust capabilities despite moderate challenges. Sensor networks secured third position (Qj = 0.315908), showing balanced performance across criteria, while simulation environments and satellite images ranked fourth and fifth respectively. This ranking hierarchy provides decision-makers with valuable guidance when selecting appropriate platforms for neural network integration projects. The results highlight that options which may appear suboptimal when evaluated on individual metrics can emerge as superior choices when assessed holistically through the VIKOR methodology. These findings align with current trends in artificial intelligence development, where integration with dynamic, real-time data sources like social media proves increasingly valuable despite technical limitations. This study adds to the expanding body of knowledge on neural network applications by providing a structured evaluation framework that balances

competing criteria. For future implementations, stakeholders should consider this multi-criteria approach rather than focusing solely on individual performance metrics, as the VIKOR method effectively captures the complex interplay between technical capabilities, adaptability, long-term viability, and implementation difficulties in neural network integration projects.

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