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Multicriteria analysis computer program using classical techniques and Unified Model
Programa de cómputo de análisis multicriterio con técnicas clásicas y Modelo Unificado

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Technological Innovation: This paper presents the technological development of a software program that integrates various classic multi-criteria analysis techniques, along with the operation of an innovative technique based on the unified methodology. This approach allows for the identification of significant advances in technological innovation within this field.

Industrial Applications: In the educational sphere, specifically in postgraduate programs, it is used in courses related to operations research and multi-criteria decision-making. It also has practical applications in industry, particularly in supply chain management.

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Resumen

Con el paso del tiempo, el campo de la toma de decisiones ha adquirido una relevancia creciente, alcanzando un alto nivel de importancia en los contextos contemporáneos. En este marco, el presente artículo introduce un programa computacional multicriterio diseñado para abordar problemas complejos de toma de decisiones. El sistema propuesto integra diversas metodologías multicriterio clásicas dentro de un modelo unificado, lo que permite examinar estos desafíos desde una perspectiva más amplia.

De manera específica, el estudio incorpora métodos ampliamente reconocidos como el Modelo de Suma Ponderada (WSM), el Modelo de Producto Ponderado (WPM), el Método de Evaluación de Suma y Producto Agregados Ponderados (WASPAS), el Método de Organización de Clasificación de Preferencias para Evaluaciones de Enriquecimiento (PROMETHEE II), la Técnica para el Orden de Preferencia por Similitud con la Solución Ideal (TOPSIS) y el Método de Optimización

Multicriterio y Solución de Compromiso (VIKOR), con el objetivo de facilitar y apoyar los procesos de toma de decisiones. Además, se describen los principios operativos de cada metodología y se proporcionan los códigos de programación (códigos QR) para mejorar la visualización y accesibilidad.

La herramienta propuesta presenta contribución tanto en el ámbito académico, científico y tecnológico. El software desarrollado integra con éxito estas seis técnicas clásicas de toma de decisiones multicriterio (MCDM) en un único entorno computacional, junto con la Metodología Unificada propuesta. El sistema permite generar clasificaciones, almacenar resultados intermedios y exportar soluciones finales en formato CSV. La implementación experimental demostró la correcta ejecución de todos los algoritmos incorporados, proporcionando un entorno unificado para el análisis multicriterio en aplicaciones académicas e industriales.

Palabras clave: Programa informático, MCDM, WSM, WPM, WASPAS, PROMETHEE, VIKOR, TOPSIS, metodología unificada.

Abstract

Over recent decades, research on decision making has expanded significantly, becoming a key area within computer science, particularly in fields concerned with data-driven methods, intelligent computational systems, and algorithmic optimization. Within this context, this article introduces a computational tool designed to support the analysis of decision problems involving multiple criteria. The system brings together several well-established multicriteria decision-making approaches within a single framework, allowing these problems to be examined from a broader and more methodologically consistent standpoint.

The study incorporates a set of widely recognized multicriteria decision-making methods, including the Weighted Sum Model (WSM), the Weighted Product Model (WPM), the Weighted Aggregated Sum Product Assessment (WASPAS), the Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE II), the Technique for Order of Preference by Similarity to the Ideal Solution (TOPSIS), and the Multicriteria Optimization and Compromise Solution (VIKOR). The integration of these approaches aims to enhance and support structured decision-making processes. Additionally, this document details the fundamental operating principles of each method and provides their corresponding programming implementations. These implementations are made available through QR codes to improve accessibility, comprehension, and ease of use. The proposed tool contributes directly to academic, scientific and technological domains.

The developed software successfully integrates these six classic multi-criteria decision-making (MCDM) techniques into a single computational environment, along with the proposed Unified Methodology. The system allows for generating rankings, storing intermediate results, and exporting final solutions in a CSV format. Experimental implementation demonstrated the correct execution of all incorporated algorithms, providing a unified environment for multi-criteria analysis in academic and industrial applications.

Keywords: Computer program, MCDM, WSM, WPM, WASPAS, PROMETHEE, VIKOR, TOPSIS, unified methodology.

1. Introduction

As multicriteria decision making tackles a wide range of issues, it has become increasingly important in the modern era. This approach can be used in both academic and industrial settings. Because these advancements are applicable in fields such as supply chain management and other engineering specialties, the creation and innovation of computational programs have greatly aided in the adaptation of multicriteria decision making within the context of Industry 4.0 (Zhang et al., 2020).

This background highlights the significance of computational tools in contemporary decision science. These solutions are primarily concerned with data management and analysis in scenarios involving large datasets and multiple assessment criteria. As a result, they can consider the preferences, constraints, and unique situations of each decision maker. By employing algorithm-based processes to generate solutions that adhere specific requirements and application settings, these systems provide structured decision support.

Despite the increasing availability of computational tools for multicriteria decision making (MCDM), most existing software implementations focus on a single methodology or provide only a limited subset of classical techniques. Consequently, researchers and practitioners often need to rely on multiple software environments to compare results obtained from different MCDM methods. This fragmented approach complicates methodological consistency, limits the direct comparison of alternatives, and increases the time and effort required to perform comprehensive decision analyses. Furthermore, the lack of an integrated computational environment capable of incorporating the principal classical MCDM techniques restricts users' ability to obtain consistent results under a common analytical framework, making the interpretation and comparison of outcomes more challenging for both researchers and decision-makers.

Although several computational implementations of individual MCDM methods have been reported in the literature, few studies have proposed an integrated computational environment capable of combining multiple classical techniques within a unified computational framework while simultaneously allowing the storage, comparison, and aggregation of their results. Most existing implementations focus on a single methodology rather than providing an environment that supports comparative multicriteria analysis under a common analytical structure. This lack of integrated computational platforms represents the research gap addressed in this study.

To overcome these limitations, this research proposes the development of an integrated computational platform named MCDM LAB, which incorporates six widely used classical MCDM techniques (WSM, WPM, WASPAS, PROMETHEE II, TOPSIS, and VIKOR) together with a Unified Methodology that enables the aggregation of their individual results into a single decision-support framework. The proposed software contributes by providing a unified computational environment that facilitates comparative analyses, improves methodological consistency, and supports both academic and industrial decision-making applications.

Computational decision-support systems also contribute to reducing human error when processing large volumes of complex information. By automating mathematical procedures and providing systematic evaluations, these tools improve the objectivity, consistency, and reliability of multicriteria analyses (Wu et al., 2022). Consequently, computational implementations enhance the quality of decision-making by supporting more transparent and reproducible evaluation processes.

From an industrial perspective, multicriteria decision-making (MCDM) software plays a fundamental role in supporting managerial and operational decisions. Organizations frequently face complex decision-making problems involving resource allocation, risk management, supplier selection, and supply chain optimization. In these contexts, MCDM tools provide a systematic framework for evaluating financial, operational, and strategic criteria simultaneously, enabling decision-makers to select alternatives based on comprehensive and objective analyses (Belton & Stewart, 2002; Haider et al., 2023). By integrating information from multiple organizational dimensions, these tools improve decision quality, reduce uncertainty, and contribute to enhanced organizational performance.

Among the various industrial applications of MCDM, supplier selection represents one of the most extensively studied and practically relevant problems. Multicriteria techniques enable organizations to evaluate suppliers based on cost, quality, delivery performance, production capability, and regulatory compliance, facilitating decisions that are better aligned with long-term organizational objectives (Jalil et al., 2023). Consequently, the adoption of integrated MCDM software not only improves decision quality but also strengthens organizational competitiveness in increasingly dynamic and globalized markets. Given this context, the main purposes of this research are as follows:

- To identify the advantages and limitations associated with the use of multicriteria decision-making tools in higher education, particularly in areas such as operations research and inventory planning.
- To analyze the application of MCDM software in industrial settings, with emphasis on its role in supporting strategic decision-making processes such as supplier selection and supply chain optimization.
- To compare the effectiveness of classical MCDM techniques with more recent approaches, considering aspects such as accuracy, response time, and user acceptance.
- To propose improvements in the design of multicriteria decision-making tools aimed at maximizing their applicability and usability in both academic and industrial environments.

This study is guided by specific objectives and a set of research questions that structure the analysis:

How can using a multicriteria decision-making system based on classical methods improve the accuracy and efficiency of academic decision-making, especially in areas like operations research and inventory management?

What are the most important advantages and disadvantages of using multicriteria decision-making software in industrial management, especially concerning supplier selection and logistics optimization?

What are the differences in the quality and effectiveness of decisions made with traditional MCDM methods compared to those made with more advanced methods, like AI algorithms or predictive analytics?

How can multicriteria decision-making technologies help businesses in highly competitive and globalized industries become more sustainable and competitive?

When developing or updating MCDM software, what factors must be considered to ensure it works well and is user-friendly in both academic and industrial environments?

2. Background

The next section explains the theoretical underpinning of the multicriteria decision making program and gives a detailed look at the classical models that make it up.

2.1. Multicriteria decision-making

This subject in question involves a collection of strategies designed to prioritize alternatives by identifying evaluation criteria within a particular decision problem (González & Ríos, 2003). Moreover, these methodologies have been extensively employed to assist decision-makers by facilitating choices that align with their preferences and contextual circumstances, irrespective of the domain of application.

The decision-making process can be organized into four primary components (Ho, 2008), as outlined below.

The initial phase involves problem identification and analysis, considering the evaluation criteria, information accessibility, and potential conflicts among various stakeholders. These requirements are generally associated with the diagnostic severity of the issue, which may warrant the utilization of multiple multicriteria methods or techniques.

The second stage entails the identification of viable alternatives. Such possibilities are delineated based on the established evaluation criteria and may arise either before the examination of the chosen procedures or during their formulation. Although the number of alternatives is often restricted in real-world scenarios, the spectrum of potential options can be quite extensive.

The third stage emphasizes the identification of evaluative criteria. To ensure the analysis is meaningful and the problem is accurately delineated, it is necessary to have more than two criteria. The chosen criteria must fulfill two essential requirements. Initially, it must be quantifiable, guaranteeing the availability of adequate data for examination. Secondly, they must be pertinent, in that they affect the interests of various stakeholders or decision-makers. Criteria may be categorized as either cost-type or benefit-type, contingent upon the individual application (Zargami & Szidarovszky, 2011).

The fourth and last step pertains to the decision-making process, encompassing the selection of suitable data collection and evaluation methodologies from a multicriteria standpoint. At this juncture, various criteria are concurrently evaluated to ascertain the most appropriate solution. The allocation of weights to each criterion is crucial, underscoring the significance of various weighting and assessment methodologies.

Furthermore, collaborative decision-making methodologies are analyzed in contexts that may not require multiple decision-makers, focusing specifically on the active engagement of decision makers in the discourse around evaluation factors.

The science of decision-making has played a fundamental role in research and development. As a result, it has been the subject of global database searches. Through bibliometric analysis, indicators related to the number of citations and documents have been evaluated across different time periods. These periods span from 2014 to 2017, followed by the years 2018 and 2019, and finally, the period from 2020 to 2023. These bibliometric results are presented in Figure 1.

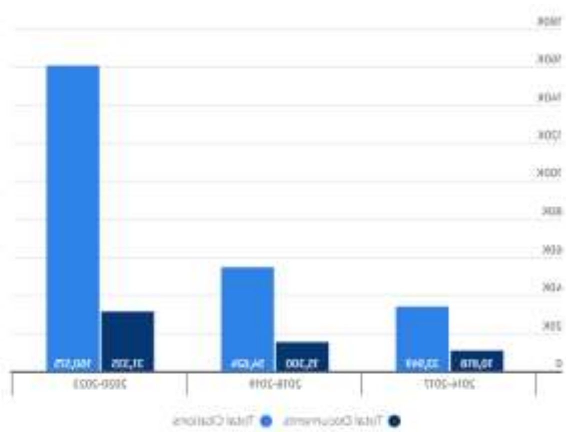

Figure 1. Documents and citations through the years.

Furthermore, the most cited sources, according to the analysis, for the 2014-2017 period are presented in Figure 2.

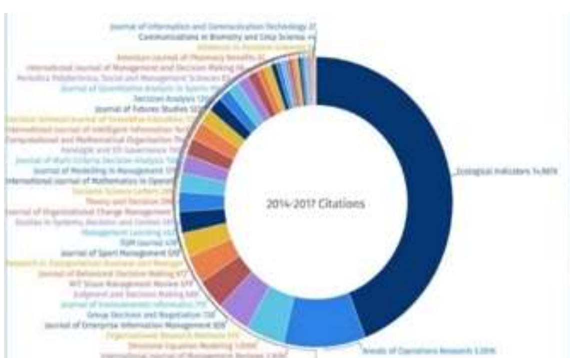

Figure 2. Citations of documents under the branch of decision science (2014-2017).

The corresponding distribution of citations for 2018-2019 is presented in Figure 3.

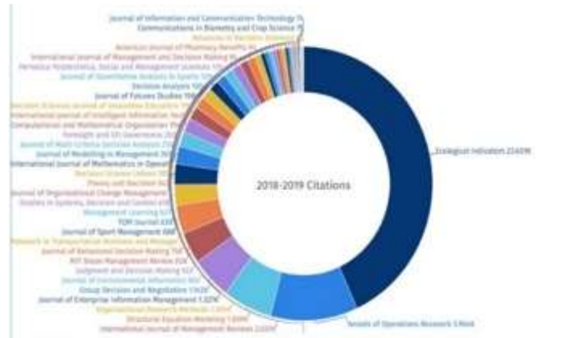

Figure 3. Citations of documents under the branch of decision science (2018-2019).

Finally, the distribution of citations for 2020-2023 is presented in Figure 4.

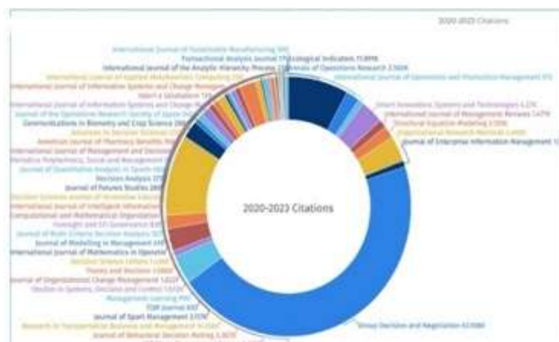

Figure 4. Citations of documents under the branch of decision science (2020-2023).

According to the previously presented figure, an increase in the number of citations over time is observed, particularly in high-impact journals. This rise suggests the growing relevance of this field today. Additionally, the methods employed in each document focus on specific problems or particular areas of development. The following section details the methods used in the present research.

2.2. Weighted Sum Model (WSM)

The weighted sum model is one of the simplest and most widely used methods. Its purpose is to evaluate alternatives and select the best option based on a predefined set of criteria. By way of example, Rao and Venkatasubbaiah (2016) used this method in the analysis of one-dimensional problems, relying on computational tools within the field of industrial machinery. Likewise, the methodology has been applied to assess the competencies of industrial workers, allowing for the identification of the most suitable alternative based on different criteria and available options.

Finally, once the results are obtained, the alternative that achieves the highest value is selected, as it is considered the most favorable option for the decision-maker.

2.3. Weighted Product Model (WPM)

This strategy is frequently utilized to address selection issues in scenarios with multiple alternatives, such as the selection of mobile phones or electronic tablets. Within this comparative framework, decision-making is facilitated by the application of weighted criteria domains (Atmojo et al., 2014). The concept has also been utilized in the food business to tackle food scarcity, with decisions regarding food selection informed by the available possibilities to attain the best results (Adiyendi, 2015).

2.4. Weighted Aggregate Sum Product Assessment (WASPAS)

The Weighted Aggregated Sum Product Assessment (WASPAS) method is a combination of two well-known models: the Weighted Sum Model (WSM) and the Weighted Product Model (WPM). This method is typically used to help decision-makers choose among multiple alternatives. One of its primary advantages is that it´s easy to use and computationally simpler than earlier methods. WASPAS has also demonstrated its ability to provide dependable rankings of alternatives across many application contexts (Chakraborty et al., 2015).

WASPAS has been widely used a lot to solve design and production problems. Chakraborty et al. (2015) assert that prevalent applications include the selection of flexible manufacturing systems, machinery within flexible manufacturing cells, autonomous vehicles, fleet management systems, and industrial robots. The method has consistently yielded favorable outcomes across several application domains.

2.5. Preference Ranking Organization Method for Enrichment Evaluations II (PROMETHEE II)

This multicriteria approach is a useful method for weighing the advantages and disadvantages of different choices and strategies when making complex decisions. One of its key features is the availability of various selection tools that let users choose among options based on their specific priorities. Consequently, the method is especially helpful for overcoming the limitations of other methods and managing situations involving diverse and sometimes conflicting criteria (Tuzkaya et al., 2010).

The PROMETHEE II method illustrates how a decision-maker perceives the differences between pairs of alternatives for each criterion being evaluated. Depending on the type of criteria, different preference functions can be used to better reflect the evaluator’s judgment (Dağdeviren, 2008). This method is commonly used in Decision and Prediction Models (DPM), especially in finance, where it helps with detailed and organized analysis in both business and industrial settings (Mousavi & Lin, 2020). It has also been used in robotics, where it facilitates improved decision-making by building upon insights gained from earlier studies (Taillandier & Stinckwich, 2011).

2.6. Technique for Order Preference by Similarity to the Ideal Solution (TOPSIS)

This approach is based on the idea that the best choice is the one that is closest to an ideal reference point, which is measured by the

Euclidean distance. Therefore, preferences are determined by how similar each alternative is to the ideal solution (Shen et al., 2018). This method is commonly employed in academic research, particularly in contexts where the recruitment of suitable personnel is crucial to organizational performance. Using this method, decision-makers can consider a broader range of factors during the selection process (Kelemenis & Askounis, 2010).

This method has also been used to compare different alternatives based on various time-related criteria. For example, it has been applied in research to track the development of the information society in regions such as the European Union (Łatuszyńska, 2014).

2.7. VIKOR

The VIKOR approach is a well-known method for addressing multi-objective optimization and finding a compromise in decision-making. Its primary purpose is to assist in decision-making when the evaluation criteria are ambiguous or conflicting. The method also highlights the importance of obtaining input from all stakeholders, considering multiple alternatives, and identifying solutions that address challenges with conflicting attributes. This assists decision-makers in finding optimal solutions.

In this context, “compromise” refers to an agreed-upon solution that is as close to the ideal option as feasible achieved through a consensus-based process. VIKOR has been highly beneficial in academic settings, such as in the selection of faculty members. The method serves as a valuable addition to the field of decision science (Radhika et al., 2013) as it simultaneously evaluates multiple factors, such as technical expertise, communication skills, and professional experience.

2.8. Positional Values for the Unified Methodology

In the context of the unified methodology, positional values are represented as numerical digits assigned to specific positions in the equation. They function similarly to weighting factors; however, they are only applied after the user has evaluated different classical multicriteria decision-making methods according to their preferences. These positional values are defined as decimal numbers and are symbolically denoted as a1, a2, a3, a4, a5 and a6.

Once numerical values are assigned to each position, they are incorporated into the corresponding unified methodology equation, where they are substituted to perform the final computation.

3. Algorithmic implementation

The software was developed utilizing C#, a high-level, object-oriented programming language integral to the Microsoft .NET framework. Selecting this language enables users to fully utilize the pre-existing libraries within the .NET framework. C# offers access to an extensive array of development tools within the .NET framework, facilitating the creation of more robust system architectures and improving the application's overall visual design.

This research effort involved the development of several user interface components, including forms, text boxes, buttons, panels, DataGridView controls, toolbars, and labels. These components were utilized in the development of the computational algorithms associated with each technique. The subsequent phases delineate the implementation of the Weighted Sum Model (WSM) multicriteria technique. The WSM operation diagram is shown in Annex 1.

Given the operation diagram, the core coding relies on generating a weighted normalized matrix. This matrix is computationally obtained from the mathematical equation characterizing the Weighted Sum Model (WSM) methodology. Subsequently, the results are stored in the normalized matrix for use in the Unified Methodology.

Additionally, the computational algorithm corresponding to WSM is accessible through the QR code shown in Figure 5.

Figure 5. WSM computational algorithm.

In the analysis, the computational algorithm, like other incorporated techniques, operates based on the selection criteria and weight values. This generates results based on a normalized and weighted matrix. The system also allows saving these results for subsequent reuse in the Unified Methodology.

Regarding the computational algorithm of the WPM methodology, its functioning is similar, following the same algorithmic principle. The difference lies in the final mathematical equation, as shown in the operation diagram in Annex 2.

In the analysis, the distinction between the WPM methodology and the WSM methodology lies in its final mathematical equation. The computational algorithm can be accessed through the QR code shown in Figure 6.

Figure 6. WPM computational algorithm.

In the analysis, the main difference lies in the weighted normalized matrix, as it is at this point that the mathematical equation identifying the algorithm is found. Subsequently, similar to other methodologies, the results from this matrix can be stored in the internal memory of the computing program for later use in the Unified Methodology.

On the other hand, the WASPAS methodology offers a more developed process compared to WPM and WSM, as it results from their fusion. Additionally, it is necessary for the user to input an additional value called ‘lambda’ for its operation, as without this value, the algorithm cannot be executed. Its overall operability is illustrated in Annex 3.

The Annex 3 diagram illustrates the behavior of the algorithm and, in particular, shows its functionality through the final mathematical equation. Figure 7 provides QR-code access to the associated computational algorithm.

Figure 7. WASPAS computational algorithm.

The WASPAS computational algorithm, like the other incorporated methods, produces its results based on the criteria and weights provided by the user. However, unlike the previous methodologies (WSM and WPM), the WASPAS code generates a final matrix based on the corresponding normalized weighted matrices of WSM and WPM. This final matrix is obtained by executing the WASPAS algorithm, where a user-entered lambda value is requested.

Furthermore, the results are stored internally for use in the Unified Methodology. On the other hand, the implementation of the PROMETHEE II methodology is more complex, as its mathematical algorithm involves continuous interaction with all alternatives. In other words, each alternative is compared, and the resulting value is substituted into the final equation that identifies it. The process is illustrated in Annex 4.

The PROMETHEE II algorithm is based on the minimum and maximum values to establish comparisons and perform the final operation based on the cells of the corresponding matrix. The generation of these results is based on the evaluation of the differences for each alternative entered by the user, as well as on the calculation of the negative and positive flow for each criterion, together with the calculation of the total flow.

As a result, the computational algorithm is derived from the process operation diagram and is available through the QR code shown in Figure 8.

Figure 8. PROMETHEE II computational algorithm.

Finally, the algorithm generates the weighted normalized matrix, and the values are stored internally in the computer program for reuse in the Unified Methodology. Next, the TOPSIS methodology is shown, and its operation process is visualized in the operation diagram in Annex 5.

The TOPSIS computational algorithm is less complex compared to PROMETHEE II, as it does not require extensive compilation; it relies solely on the type of criteria and the Euclidean distance. The algorithm generates two results: the ideal values (best) and the non-ideal values (worst). Finally, the results are obtained using the weighted normalized matrix and can be stored internally for later reuse.

The TOPSIS computational algorithm is accessible through the QR code shown in Figure 9.

Figure 9. TOPSIS computational algorithm.

Regarding the final classic multicriteria decision-making technique, the operation diagram for the VIKOR methodology is shown in Annex 6. The diagram represents the generation of the results associated with each mathematical equation that composes it.

The VIKOR methodology, like previous methodologies, is based on the types of criteria related to ideal (best) and non-ideal (worst) values. Its computational algorithm generates a final value using the weighted normalized matrix. These values can be stored internally for later use in the Unified Methodology.

The corresponding computational algorithm is embedded in the QR code shown in Figure 10.

Figure 10. VIKOR computational algorithm.

Each of these algorithms is essential for the creation of the Unified Methodology. Its implementation plays a fundamental role in improving the precision of multicriteria decision-making. The combination of the six classic methodologies incorporated in the multicriteria computing program (WSM, WPM, WASPAS, PROMETHEE II, TOPSIS and VIKOR) contributes from both a technological and scientific perspective.

This operation is based on the following process:

It begins with the stored results of two or more multicriteria methodologies; these can include any combination of the following: WSM, WPM, WASPAS, TOPSIS, PROMETHEE II, and VIKOR. Therefore, weighting or positional values (a_n) are entered for each generated methodology. Finally, the equation that represents the Unified Methodology is implemented:

$$A^{MCDM\ LAB} = a_1 A^{WSM} + a_2 A^{WPM} + a_3 A^{WASPAS} + a_4 A^{TOPSIS} + a_5 A^{PROMETHEE\ II} + a_6 A^{Vikor} \quad \textbf{(Eq. 1)}$$

The behavior of this process is shown in Annex 7.

In this way, the computational code that represents the Unified Methodology is shown through the QR code in Figure 10.

Figure 10. Unified Methodology computational algorithm.

The behavior of the computational algorithm is encoded by a series of conditions. First, it displays the results of the classic methodologies that the user has previously stored in the output interface. Then, the user or decision-maker assigns positional values to execute the computational algorithm corresponding to the Unified Methodology.

It is important to note that if the system does not find an assigned positional value, it will automatically be assigned positional value, so that the total sum is equal to 1. When the algorithm is executed, results are generated in the matrix associated with this methodology.

4. Results

The results of the code processing are

satisfactory, demonstrating the program´s interface and its operation centered on the Unified Methodology. First, the program initialization screen, shown in Figure 11, presents the name “MCDM LAB”, meaning “Multicriteria Decision Making Laboratory”.

Figure 11. MCDM LAB home screen.

Considering the implementation of the algorithm, when any classic methodology is executed and the results are displayed, the user has the option to execute the Unified Methodology. If the user decides to do so, the system displays a text box asking whether they want to save the final results of the selected methodology. If yes, these results are stored in the internal memory. Subsequently, using an “if” condition, the matrices necessary to process the data are initialized.

This data processing involves assigning value types to quantitative data, that is, processing both integer and float data as entered by the user. Once all the required data has been processed, it is used in a loop to multiply it by each positional value entered by the user. Otherwise, by default, a value of 0.25 is used (represented in the code by the variables VP1, VP2, VP3, VP4, VP5, and VP6). These positional values are entered into a special matrix or table for the operability of the Unified Methodology. Then, a final cycle is initiated for the sum of the values resulting from the product of each multicriteria methodology generated by its positional value, and finally, these results are displayed in the corresponding matrix. The resulting interface is shown in Figure 12.

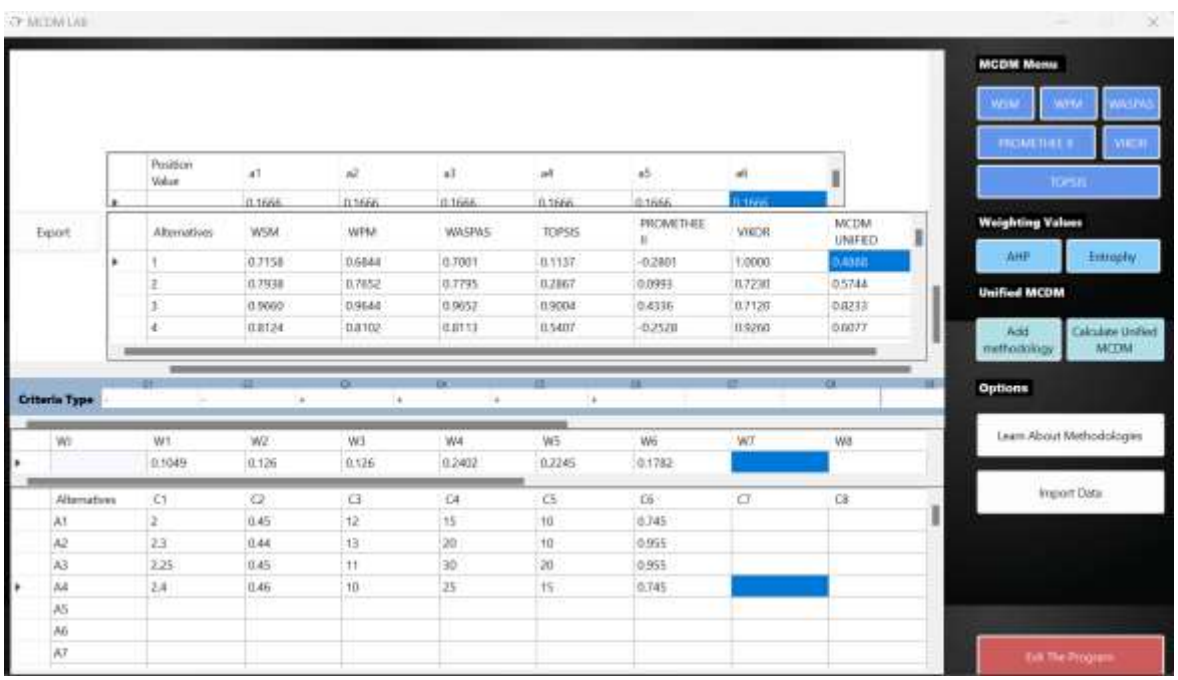

Figure 12. Unified methodology.

In this way, the Unified Methodology is created, and in addition, the option to generate an export file in .csv format is offered. The user can save a copy of the results matrix, as shown in Figure 13.

	A	B	C	D	E	F	G	H
1	Alternatives	WSM	WPM	WASPAS	TOPSIS	PROMETHEE	VIKOR	MCDM UNIFIED
2	1	0.71577235	0.68435783	0.70006509	0.1137328	-0.2801375	1	0.48876951
3	2	0.79380072	0.76516385	0.77948229	0.28674517	0.09931806	0.72302788	0.57435982
4	3	0.96595983	0.96441282	0.96518633	0.90038178	0.43364583	0.712	0.82326833
5	4	0.81241781	0.81024832	0.81133307	0.54070038	-0.2528264	0.92602757	0.60774027
6								

Figure 13. Unified methodology data export.

It is important to highlight that the unified methodology is beneficial for the user, since it allows generating precise results based on the perspective of the six methodologies incorporated in the program. Furthermore, the interface is user-friendly, and its use is intuitive, as long as the appropriate data is available for simulation and resolution of problems related to the incorporated multicriteria techniques.

4.1. Validation of the TOPSIS Algorithm

To verify the correctness of the TOPSIS algorithm implemented in MCDM LAB, a benchmark case study reported by Dhanalakshmi et al. (2022) was reproduced using exactly the same decision matrix, criteria weights, and evaluation parameters described in the original publication. The selected study addresses a biomass material selection problem based on a hybrid FAHP–TOPSIS model and reports a final preference value of 0.6699 for the best alternative.

The following section presents the input information proposed by the authors; which ranges from the criteria and alternatives to the respective weights of each criterion in the computer program developed in this project, starting with the decision matrix shown in Figure 14.

Wi	W1	W2	W3	W4	W5	W6	W7	W8
	0.0676	0.1979	0.1409	0.3342	0.0992	0.0404	0.1198	

Alternatives	C1	C2	C3	C4	C5	C6	C7	C8
A1	18	32.1	24	79	10.7	6	4.3	
A2	17	48.4	34.6	73.7	18.8	3.5	4	
A3	27.5	47.5	25	79.2	15	3.6	2.2	
A4	17.5	37	22.5	58.8	21	16.1	4.1	
A5	13.4	39	47.6	80.2	11.3	5.4	3.1	
A6	15	52.5	32.5	78.39	6.54	12.77	2.3	
A7	44	27.7	21.6	67.2	19.7	11	2.1	

Figure 14. Decision matrix introduced in MCDM LAB.

As shown in Figure 14, the table displays the input data such as the type of criterion, the respective weights and the alternatives. The results of the normalized matrix are shown below (Figure 15).

Normalized Decision Matrix

C1	C2	C3	C4
0.2840	0.2925	0.2934	0.4026
0.2683	0.4410	0.4229	0.3756
0.4339	0.4328	0.3056	0.4037
0.2761	0.3372	0.2750	0.2997
0.2114	0.3554	0.5818	0.4088

Normalized Decision Matrix

C5	C6	C7
0.2601	0.2384	0.4950
0.4570	0.1390	0.4605
0.3646	0.1430	0.2533
0.5105	0.6396	0.4720
0.2747	0.2145	0.3569

Figure 15. Normalized decision matrix (TOPSIS).

Consequently, the weighted normalized decision matrix also generated by MCDM LAB is obtained (Figure 16).

Weighted Normalized Decision Matrix

C1	C2	C3	C4
0.0192	0.0579	0.0413	0.1346
0.0181	0.0873	0.0596	0.1255
0.0293	0.0857	0.0431	0.1349
0.0187	0.0667	0.0388	0.1002
0.0143	0.0703	0.0820	0.1366

Weighted Normalized Decision Matrix

C5	C6	C7
0.0258	0.0096	0.0593
0.0453	0.0056	0.0552
0.0362	0.0058	0.0303
0.0506	0.0258	0.0565
0.0272	0.0087	0.0428

Figure 16. Weighted Normalized Decision Matrix (TOPSIS).

Therefore, the final results are shown below (Figure 17).

Results: SI+, SI-, (SI+) + (SI-) and Pi

SI+	SI-	(SI+) + (SI-)	Pi
0.0677	0.0490	0.1167	0.4195
0.0375	0.0683	0.1059	0.6455
0.0451	0.0670	0.1121	0.5974
0.0719	0.0480	0.1199	0.4005
0.0366	0.0743	0.1109	0.6699

Final Results

Pi Results	ALTERNATIVES
0.4195	A1
0.6455	A2
0.5974	A3
0.4005	A4
0.6699	A5

Figure 17. Final results of the exercise (TOPSIS).

The validation results demonstrate that MCDM LAB accurately reproduces the benchmark case reported by Dhanalakshmi et al. (2022), obtaining the same final preference value (0.6699) and selecting the same optimal alternative. This agreement confirms the correctness of the mathematical implementation of the TOPSIS algorithm and indicates that the computational procedures incorporated into the proposed software preserve the analytical behavior described in the original study.

Unlike the original study, which focuses exclusively on the application of the TOPSIS methodology to a biomass selection problem, the proposed software integrates this algorithm within a unified computational environment that also incorporates WSM, WPM, WASPAS, PROMETHEE II, and VIKOR. This integration enables users not only to reproduce individual analyses but also to compare and aggregate the outcomes of multiple classical MCDM techniques through the Unified Methodology.

From a practical perspective, this capability reduces the need to employ multiple software packages for multicriteria analysis and facilitates methodological consistency when comparing alternative solutions. Consequently, the proposed platform extends the applicability of classical MCDM methods in academic research and industrial decision-support scenarios.

Although the validation presented in this study focuses on the TOPSIS methodology, the remaining classical techniques incorporated into MCDM LAB were developed under the same modular software architecture and according to their corresponding mathematical formulations. Therefore, the TOPSIS benchmark provides direct evidence of the correctness of this specific implementation and illustrates the validation procedure that can be extended to the other incorporated methods.

4.2. Discussion

Previous studies have generally applied individual MCDM techniques to specific decision problems. For example, Budiharjo et al. (2017) compared WSM and WPM in an educational selection problem, Chakraborty and Zavadskas (2014) applied WASPAS to manufacturing decisions, Mousavi and Lin (2020) employed PROMETHEE in financial decision-making, and Dhanalakshmi et al. (2022) used TOPSIS for biomass material selection. In contrast, MCDM LAB incorporates these classical methods within a single computational environment and enables their results to be stored, compared, and subsequently aggregated through the Unified Methodology. Therefore, the principal contribution of the proposed platform lies not in replacing the individual mathematical methods, but in facilitating their integrated computational application under a common decision-support framework.

5. Conclusions

Based on the previous results, we can conclude that the multicriteria computing program is a useful and intuitive tool for users or decision-makers, since it allows them to operate the system without difficulty.

Among the classic multicriteria methodologies, the Unified Methodology stands out, which represents a scientific contribution by unifying six classic approaches. Regarding the computational algorithms of each multicriteria methodology, it is observed that the code presents a modular organizational structure, which facilitates modifications and adaptations for special situations with the aim of improving its application in scientific research problems.

The development environment utilized for software creation offers significant advantages, as it includes packages containing pre-built functions for executing mathematical computations and enhancing the overall code structure. The MCDM LAB program provides significant technical and intellectual value to decision-making by enabling users to manage certain domains more efficiently through accurate and comprehensible data.

6. References

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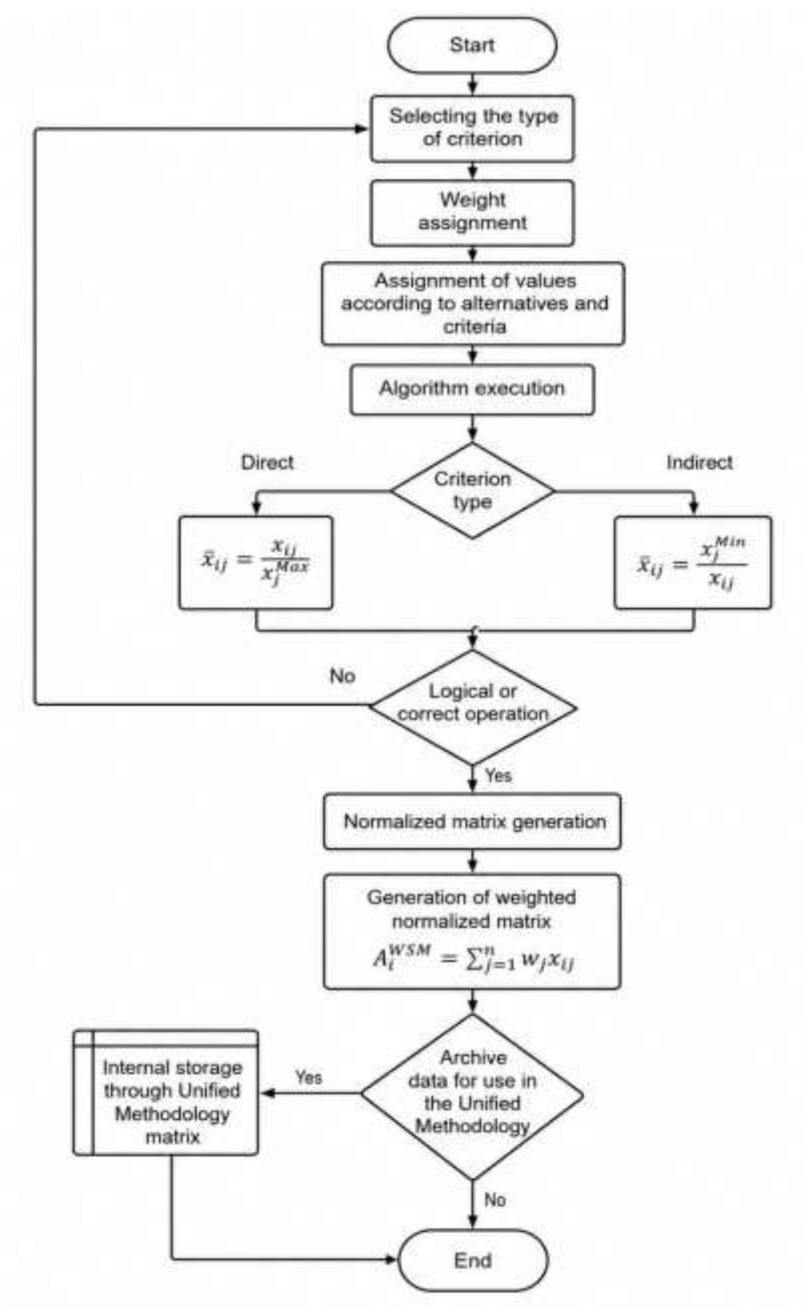
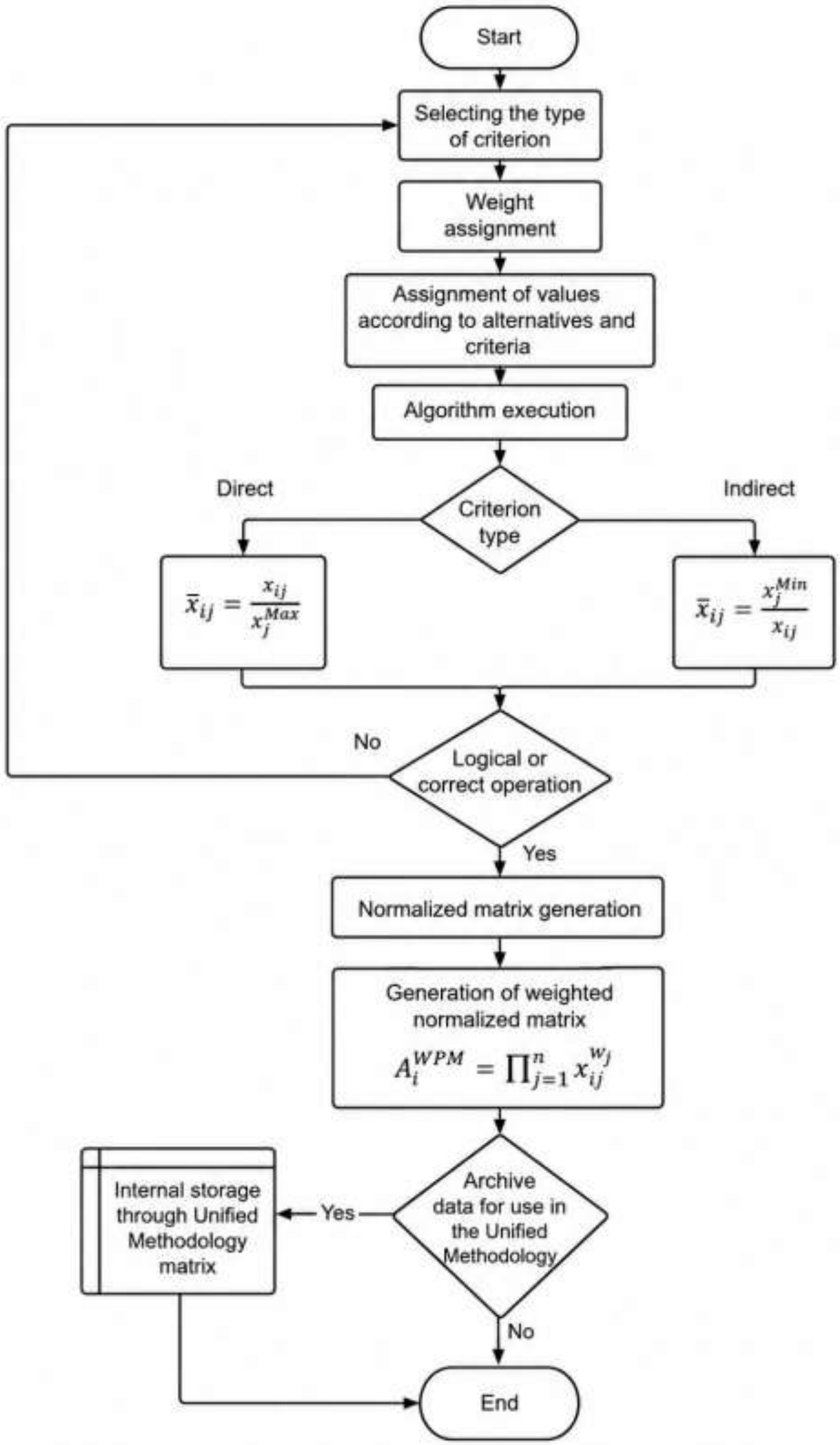
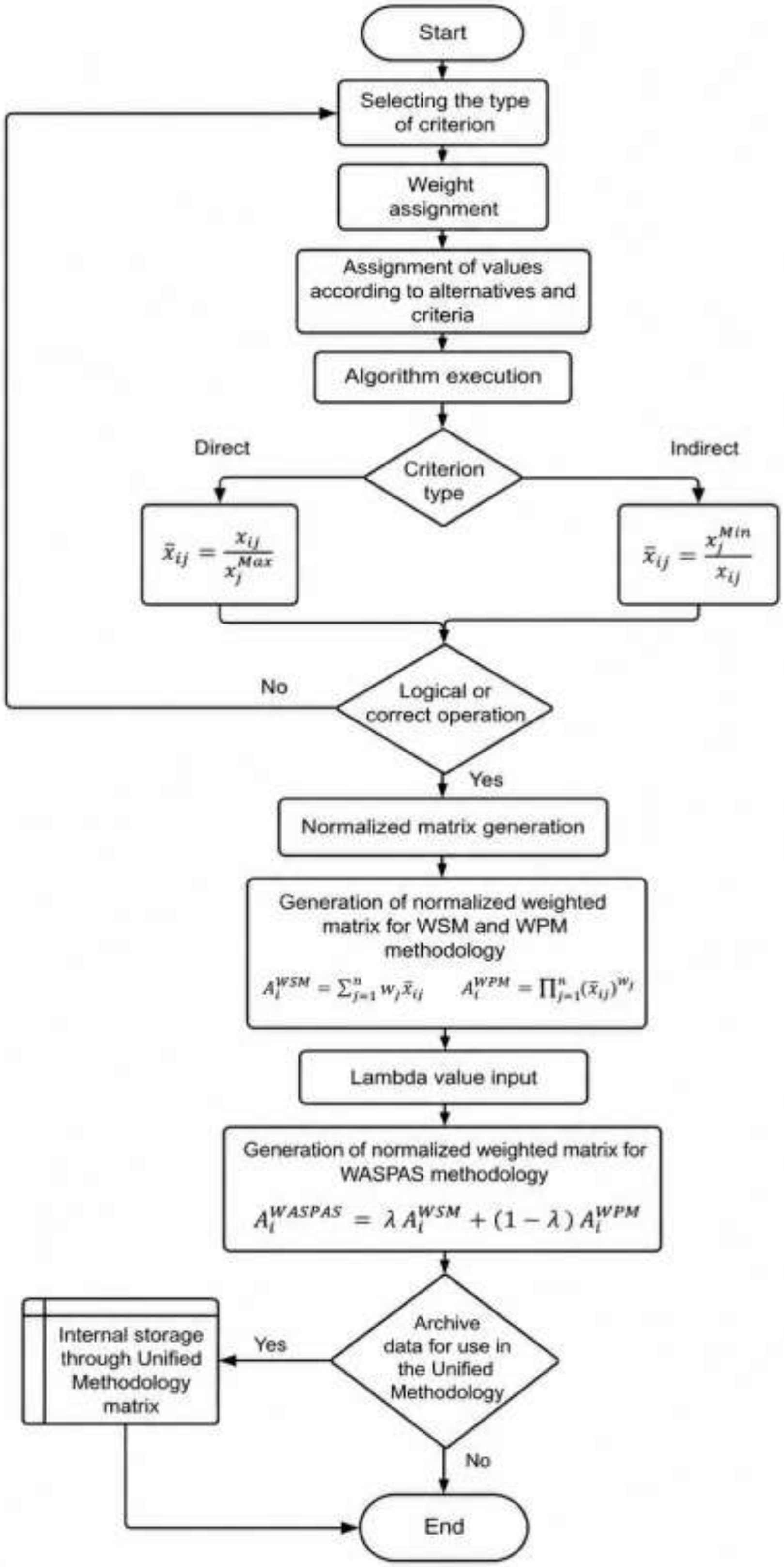


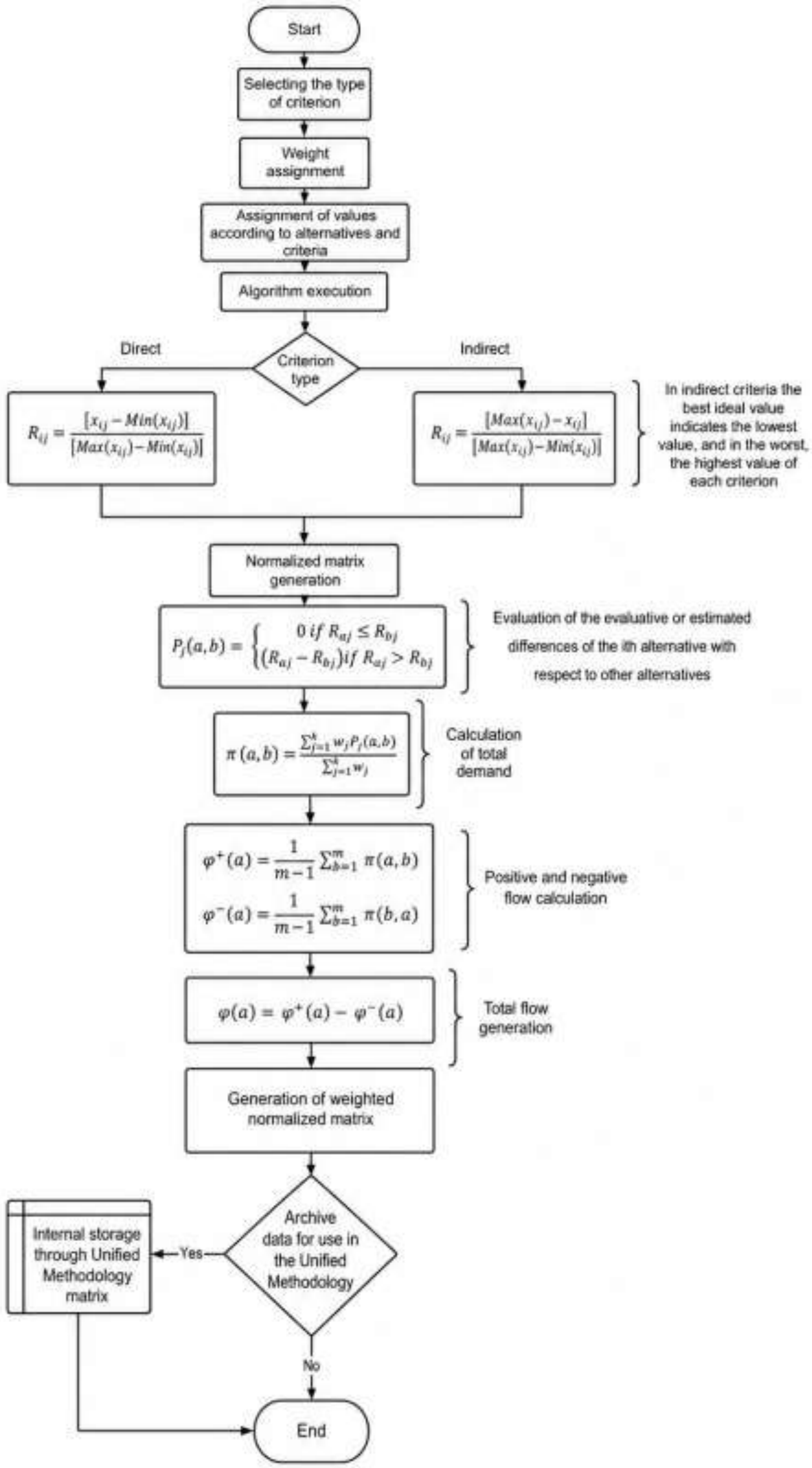
Annex 1. Operation diagram of the WSM algorithm.



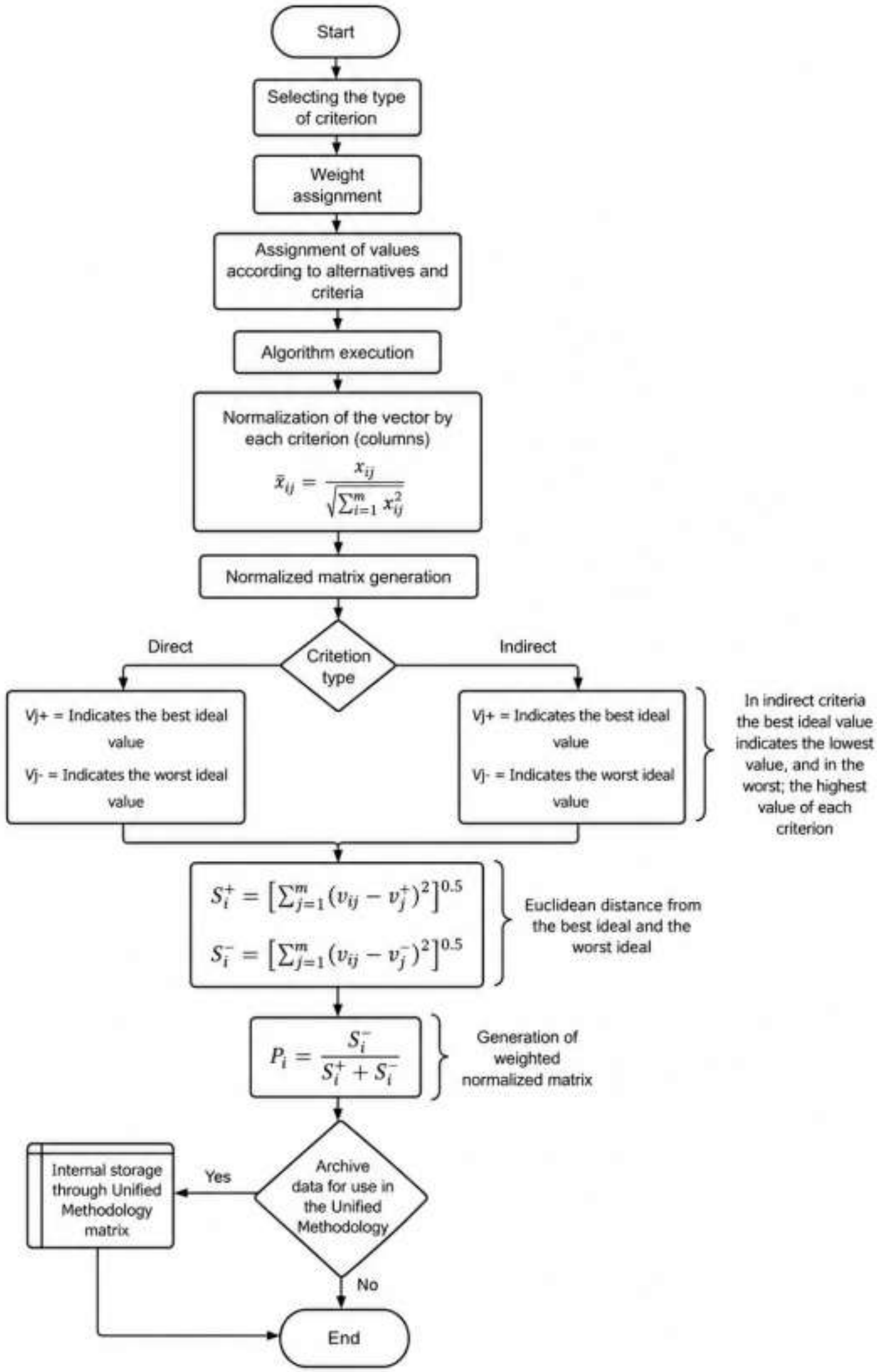
Annex 2. Operation diagram of the WPM algorithm.



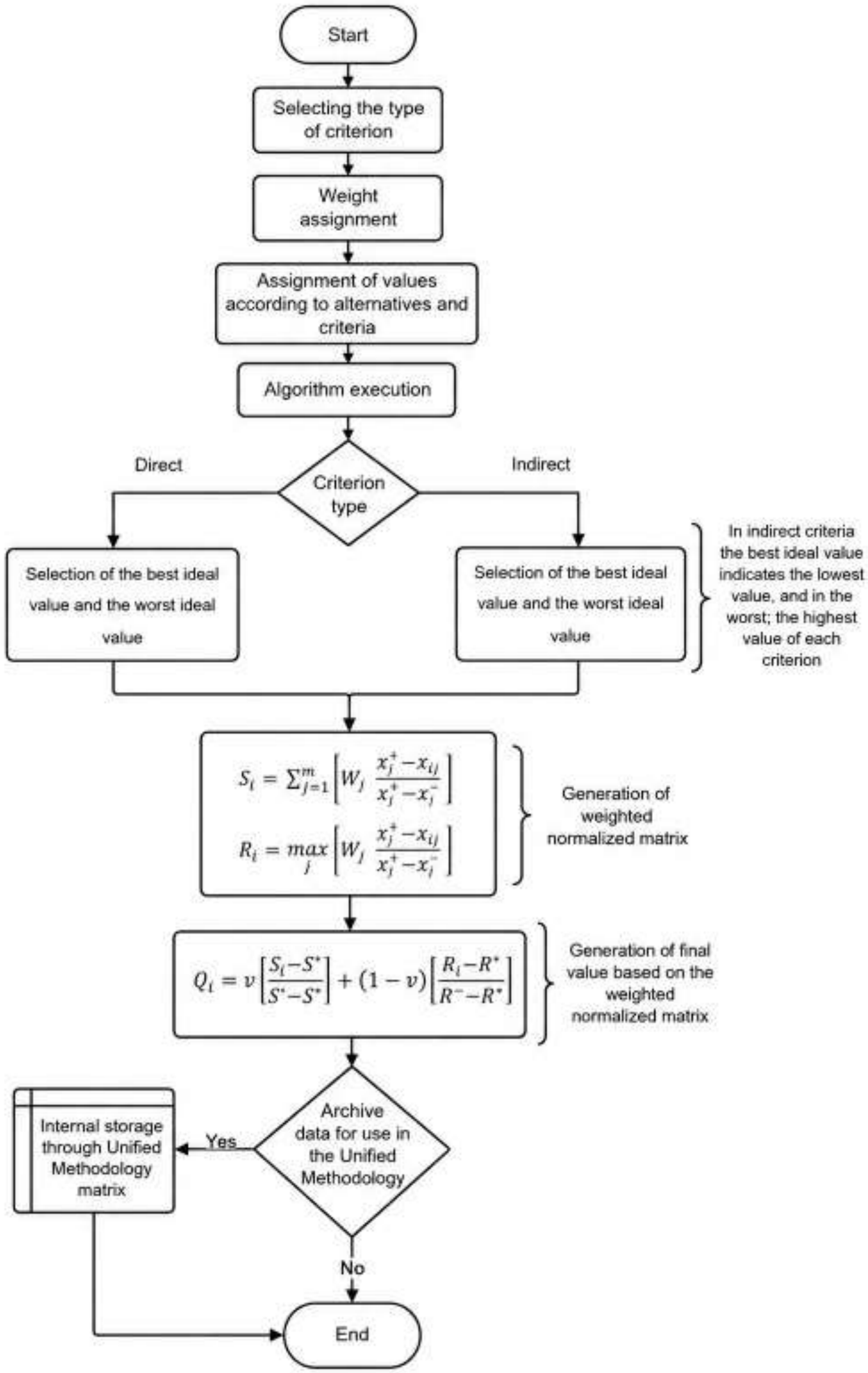
Annex 3. Operation diagram of the WASPAS algorithm.



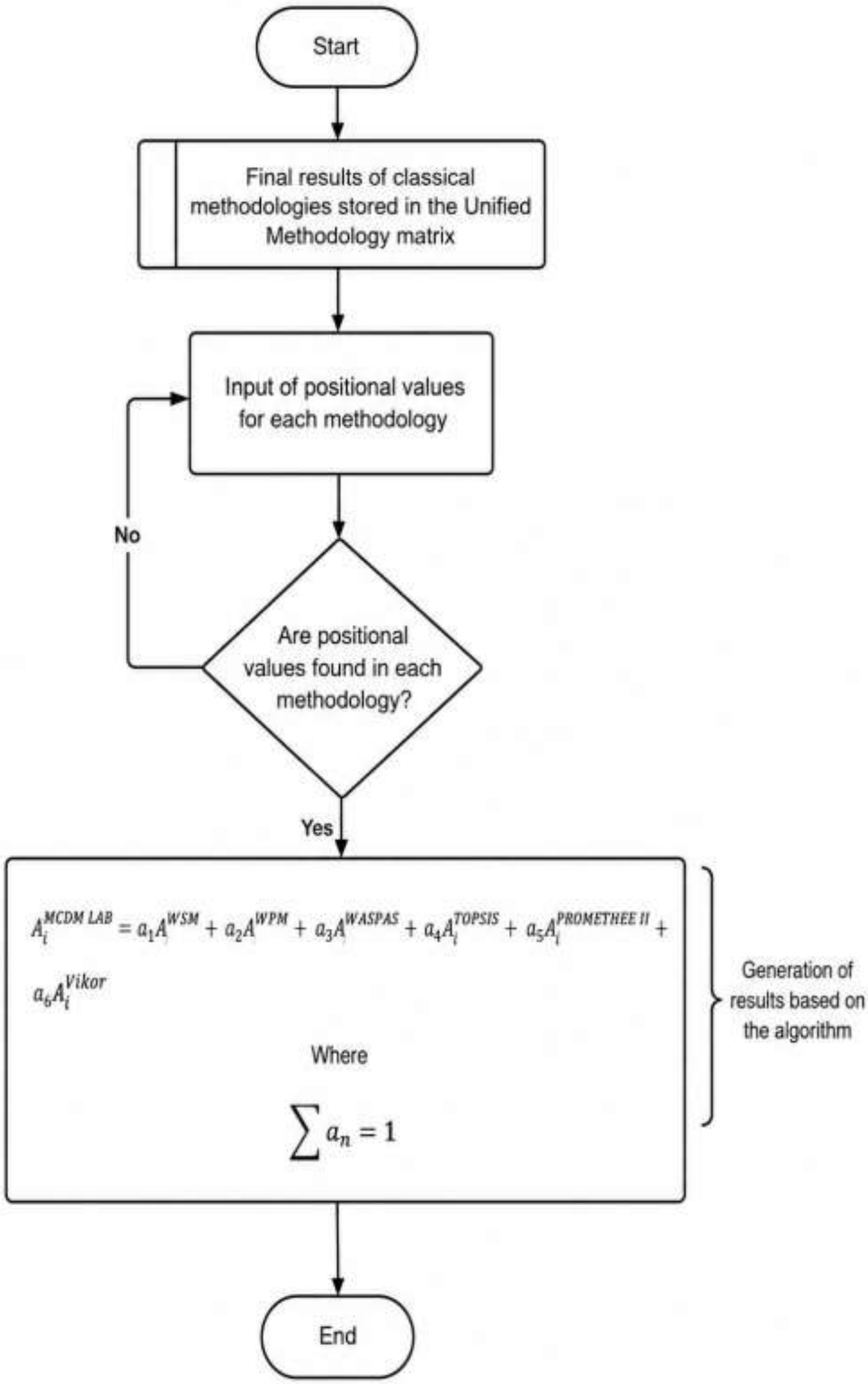
Annex 4. PROMETHEE II operation diagram.



Annex 5. TOPSIS operation diagram.



Annex 6. VIKOR operation diagram.



Annex 7. Unified methodology operation diagram.