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ORIGINAL

Web Application Development for TODIM Method Automation and Alternatives Evaluation

Desarrollo de Aplicación Web para la Automatización del Método TODIM y Evaluación de Alternativas

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ABSTRACT

The TODIM method (Tomada de Decisao Interativa Multicriterio), which in Portuguese means “Interactive and Multicriteria Decision Making”, is a process of evaluation alternatives, with various academic and professional uses. The current project focuses on the first approach, considering students, professors and investigators as the main beneficiaries and target audience. There is a shortage of software that automate the TODIM method, therefore it is proposed to develop a web application mainly using Python, HTML and JavaScript programming languages that can satisfy this necessity. To guarantee a uniformity in the results obtained by this program, samples of results obtained by this method by other researchers are taken as a basis and guide. To develop the application, the complete functioning of TODIM as an alternative evaluation approach must be understood. In a general view, TODIM uses pairwise comparisons between decision criteria while eliminating the inconsistencies that arise from such comparisons. Thus, the main idea is to measure the degree of dominance in each alternative over the others using the prospective value function. As result, it calculates the overall and partial degrees of dominance of each alternative to finally lead to a classification or “ranking” of the best alternatives.

Keywords: Alternatives; Decisions; Evaluation; Interactive; Multi-Criteria.

RESUMEN

El método TODIM (Tomada de Decisao Interativa Multicriterio) que en portugués significa “Toma de Decisiones Interactiva y Multicriterio”, es un proceso de evaluación de alternativas, con diversos usos académicos y profesionales. El presente proyecto se enfoca en la primera área, tomando a estudiantes, profesores e investigadores como principales beneficiarios y público objetivo. Existe una escasez de programas que automaticen el método TODIM, por lo que se propone el desarrollo de una aplicación web principalmente a través de los lenguajes de programación Python, HTML y JavaScript que pueda satisfacer dicha necesidad. Con el fin de garantizar una uniformidad en los resultados obtenidos por este programa, se toman como base y guía muestras de resultados obtenidos a través de este método por otros investigadores. Con el objetivo de desarrollar la aplicación, se debe de comprender el funcionamiento completo de TODIM como una estrategia de evaluación de alternativas. En líneas generales, TODIM usa comparaciones por pares entre los criterios de decisión al mismo tiempo que elimina las incoherencias que surgen de dichas comparaciones. Así, la idea principal consiste en medir el grado de dominio en cada alternativa sobre el resto mediante la función de

valor prospectivo. Como resultado, calcula los grados de dominio generales y parciales de cada alternativa para, finalmente, conducir a una clasificación o "ranking" de las mejores alternativas.

Palabras clave: Alternativas; Decisiones; Evaluación; Interactiva; Multicriterio.

INTRODUCTION

In research and development work, it is indispensable to have tools and methods that allow academics to evaluate the alternatives available in a specific project objectively. For example, an architecture project may have several alternative areas in which to select a building site. However, such work may have different criteria, such as size, cost, distance of material suppliers, and so on. Based on these criteria, an evaluation methodology can rank the alternatives according to the requirements to be met by all stakeholders.

One tool used for evaluating alternatives is the TODIM method (an acronym in Portuguese for "Interactive and Multicriteria Decision Making"). This multicriteria value function can be configured to individually evaluate the degree of dominance of different alternatives based on a pre-established set of criteria. Finally, the best alternatives meeting the project's requirements are ranked.

Thus, MCDM (Multicriteria Decision Making) methods refer to problems that involve classifying a given set of variable alternatives and identifying the optimum choice in the presence of multiple attributes/criteria that may conflict. However, while TODIM is a discrete MCDM method and can help formulate problems that satisfy customer requirements, it still demands a complex process that can become tedious as the number of alternatives and criteria to be evaluated within a single problem increases.[1]

Therefore, this project presents a development proposal for a Python-based web application to automate the procedural steps of the TODIM method. This project will be based on the original presentation of TODIM by Gomes and Lima, which is based on prospect theory.[2]

Under this approach, it is necessary to understand the entire operation of TODIM as a strategy for evaluating alternatives to develop the application. In general terms, TODIM uses pairwise comparisons between decision criteria by eliminating inconsistencies arising from such comparisons. Thus, the main idea is to measure the degree of dominance of each alternative over the others using the prospective value function. As a result, it calculates each alternative's overall and partial degrees of dominance to rank the best choices.

Therefore, to complete the project, this document is structured in distinct phases/sections that help to identify, order, and justify the definition of the problem and the phases that will allow it to be solved. From the definition of the general and specific objectives to the scopes and limitations, it will be vital to generate the features necessary to include in the software to be developed. It will also go into the main theories and concepts supporting these features and properties, the definition of TODIM, and the steps that make it up.

The authors will also include practical examples to visualize the applicability of the TODIM method in different types of projects, from site selection for a new building to resource optimization in industrial production. These examples will illustrate how automating the process through a web application can facilitate and accelerate decision-making, reducing the time required to make comparisons between alternatives and minimizing human errors that may arise during manual analysis. The proposed tool is intended to be practical, intuitive, and adaptable to different areas of study and industrial regions.

THEORETICAL FRAMEWORK

Problem definition and objectives

This project seeks to develop a web application that will automate the TODIM multi-criteria decision-making method, mainly in the academic area. By automating this method, the process of researching and evaluating multiple alternatives within a project can be streamlined.

The project will benefit all researchers and academics interested in applying the TODIM method to their research work. This is due to the function of the web application to be developed, which will consist of a tool that will speed up the evaluation process of alternatives through TODIM.

Since the application seeks to automate the previously mentioned method, it will speed up evaluation and decision-making times within the same project based on criteria pre-established by the same investigator.

The TODIM method has various applications, including evaluating energy source classification projects, engineering, optimal parameters for a predetermined process, risk analysis, and so on. Thus, any investigator and/or student can benefit from the development of the TODIM method automation application.

Objectives

TODIM is a decision-making method. It has been used to make an optimal choice within a project for each stakeholder by evaluating multiple criteria from different alternatives. However, given the considerable

number of manual calculations and processes that must be performed, it becomes long and tedious as the number of alternatives increases.

General objective

Develop a web application through Python, HTML and JavaScript programming languages that automates the TODIM (Tomada de Decisao Interativa Multicriterio) method, so that the user can enter a matrix, either through an '.xlsx' file or manually, and the program performs the entire procedure automatically.

Specific objectives

- Define any requirements and functional characteristics for the application of the TODIM Method.
- Develop an intuitive data entry environment to capture the criteria and alternatives the user wishes to evaluate.
- Integrate visualization functions to present TODIM process data and results to the user on the screen.
- Perform tests on different application cases to verify the quality of the application of the TODIM method.

Scope and limitations

Scopes

- Development of an application that automates evaluating alternatives in a project's decision-making process with defined criteria.
- The program can receive values entered manually by the user and/or previously stored in a file.
- The results obtained may be displayed on screen and exported as a file.
- The software will allow the user to re-display data stored in previously exported files, but the TODIM automation process will only work within the web application environment.
- The project will be based on the original version of the TODIM method, so any variant or modification will not be considered.

Limitations

- The web application's development will use version 0.20.3 of the JavaScript Sheet JS library to work with CSV and .xlsx files, so the use of the functions within the application will be limited to those allowed by this version.
- The program will not autocorrect erroneously entered data; the user must load data logically.

The TODIM method (Portuguese acronym for "Multicriteria Interactive Decision Making") was first defined in 1992 by Gomes and Lima. It has proven to be an especially useful tool for solving multicriteria and multi-attribute problems. Its application areas include project management in industry, commerce, or engineering.[3]

MCDM (Multicriteria Decision Making)/MCDA (Multicriteria Decision Analysis) Methods

Currently, it is possible to solve complex decision-making problems using mathematical equations based on multiple statistics, theories, and even devices that help to efficiently estimate the viable solutions to problems focused on decision-making.

Multicriteria Decision Making (MCDM) is a process of evaluation and decision-making when a person or team needs to consider several criteria or objectives. Therefore, an MCDM problem refers to the problem of ranking a feasible set of alternatives to identify the best option compared to the multiple attributes/criteria in the conflict.[4]

Thus, MCDM is a methodology that considers all the different qualitative and quantitative criteria that influence the decision-making process to find the best solution that will satisfy all the stakeholders of a project or process.

In addition, in these problems, each researcher will give different "weights" to the criteria based on the importance of each criterion in a particular case. For example, the cost and quality of specific processes are among the most common priority criteria in problems that are based on decision-making because, during the development of projects, it is common to work under a limited budget.[5]

Application Area

There may be a vast array of applications for MCDM/MCDA, as most problems involving decision-making among multiple alternatives by individuals or groups are amenable to an MCDM methodology. However, as is evident, most everyday decisions do not require an elaborate process to be conducted. This changes when large-scale, important situations are involved.

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In relevant scenarios, such as risk estimation of a project, it is essential to conduct a criteria evaluation using an efficient methodology and with the right team. Thus, an MCDM is a tool used for structuring steps, planning, and decision-making when all stakeholders possess multiple predefined criteria to find the optimal solution to a problem.[5]

Also, the several types and methods of MCDM have their own specific advantages and disadvantages that may imply multiple impacts that should be considered in decision-making, as they will affect the outcome of the decisions evaluated. For example, in Fuzzy Set Theory (FST), using imprecise inputs is possible, although this implies that it is difficult to develop.[6]

Therefore, an MCDM can have multiple applications in different disciplines, ranging from evaluating decision-making in economics, finance, architecture, engineering, and even medicine. In an article by Pramanik[6] a general review of the significant applications of MCDM in various areas and disciplines can be found. A summary of the results can be seen in the table 1.

Table 1. Application areas from MCDM

Application Areas	Application Examples
Health	Health risk assessment, Care of people at risk, General Health.
Energy Sector	Classifying renewable energy sources, Techniques for Energy Policies.
Production and Engineering	Material selection for design optimization, Optimal Process Parameters.
Organizations and Corporations	Corporate Maintainability, Corporate Systems Selection Process.
Education	E-learning, Contextual Modeling of Personalized Student Learning.
Civil Engineering	Natural Disaster Risk Analysis.
Economics and Finance	Project Portfolio Management.

MCDM (Multi-Criteria Decision Making) Method Elements

Before examining the various methods of MCDM, it is important to understand the four key elements involved in each method's operation.

- Alternatives: depending on the type of application to be given in the MCDM, any number of alternatives can be included, from a minimum of two to tens, hundreds, or thousands.
- Criteria: they are used to evaluate and compare the different alternatives available. They can be quantitative or qualitative. Five to eight criteria are usually enough.
- Weights: represent the relative importance of a criterion.
- Decision Makers: other stakeholders whose interests will be represented may also be involved. This can include one to hundreds of different people.

These elements are the properties that MCDM methods and algorithms consider to evaluate decision-making in a project or process and that will be considered throughout the development of this project.

AHP (Analytic Hierarchy Process) Method

The Analytic Hierarchy Process (AHP) was developed by Saaty in 1980 and is characterized by the use of pairwise comparison questions to obtain a matrix of the relative preference between each pair of alternatives concerning the attributes and a matrix of judgments about the relative importance of each pair of attributes.[7]

AHP also develops a linear additive model, but in its standard format, it uses procedures to derive the weights and scores achieved by alternatives based on pairwise comparisons between criteria and alternatives.[8]

Thus, to give an example, to assess the weightings, the decision-maker is asked a series of questions, each of which refers to the importance of a given criterion about another for making decisions that satisfy the interests of all the stakeholders.

It is extremely useful when making decisions about complex situations with high stakes. It stands out from other decision-making techniques because it quantifies criteria and options that are traditionally difficult to measure with hard numbers. Rather than imposing a "right" decision, the AHP method helps decision-makers find the one that best fits their criteria and their understanding of the problem.

Shannon's entropy Method

Shannon entropy measures uncertainty (or variability) related to random variables. This proposal was initially developed to weigh the homogeneity and richness of plant and animal species.[9]

Its use has been extended to many other fields:

- Information theory considers stochastic processes as sources of information.
- Nutrition, where the Shannon entropy diversity measure measures the diversity of a given diet.

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- Physic, where the thermodynamic entropy is a particular case of the Shannon entropy, can also be used to measure the amount of information in some wave functions.

Finding the appropriate weighting for each criterion is one of the main tasks in multi-attribute decision-making (MADM) problems. The Shannon entropy method is one of several methods for finding weights discussed in the literature.[10]

TODIM (TOmada de Decisao Interativa Multicriterio) Method

The main objective of the TODIM method is to compare and rank each available alternative among the rest, using a general value to evaluate and rank them according to the characteristics expected by each stakeholder.[11]

The TODIM method is internationally referenced as the only multi-criteria method based on Prospect Theory, developed by psychologists Kahneman and Tversky in 1979.[12] The TODIM method simulates human behavior when evaluating alternatives during decision-making under stressful circumstances or, in other words, under risky conditions.

In the Prospect theory, from which the TODIM method was developed, it is observed that people tend to prioritize choices that allow them to earn less to ensure a profit instead of assuming a risk that allows them to earn more. On the contrary, in scenarios where they repeatedly obtain more significant losses than gains, people choose to take risks of greater losses if they can avoid even more significant losses or gains. This concept is known as Prospect Theory.[13,14]

Figure 1 visually shows how the trend demonstrated in Prospect Theory, which is part of the foundation of the TODIM Method for evaluating alternatives, is represented in a function.

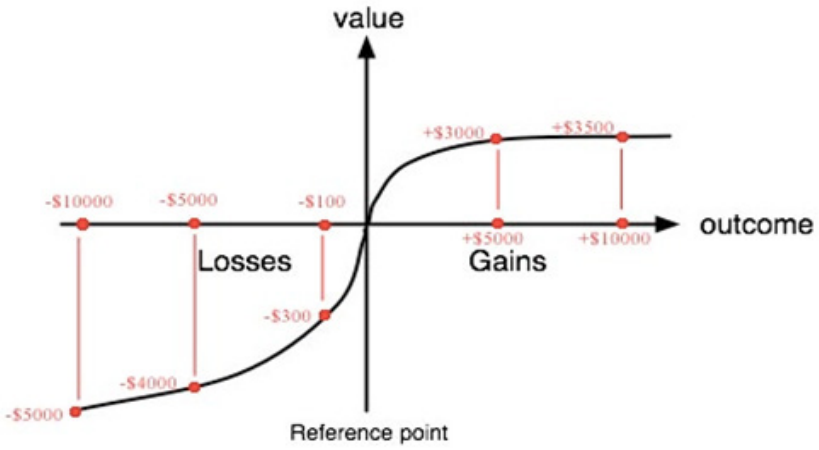

Figure 1. Value function Prospect Theory

Thanks to this psychology, TODIM is a methodology that has a wide variety of uses, which can be applied in the valuation of projects such as the classification of energy sources, engineering, determination of optimal parameters for a specific process, risk analysis, among others. Therefore, we seek to obtain great benefits from the development of an application that automates the TODIM method.

Performance and steps of the TODIM Methodology

The application of the TODIM method is an ideal tool for the classification and evaluation of alternatives based on criteria predetermined by the stakeholders according to their interests, motivations, and weightings in the decision-making process.

The steps that make up the TODIM process, and on which the development of the web application for its automation will be based, are as follows:[15]

Step 1: as a first step for the application of the TODIM method, the decision matrix must be developed and established . In this matrix, there are n and m number of alternatives and evaluation criteria, respectively.

In such a way that:

$$X = [x_{ic}]_{nxm} = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1m} \\ x_{21} & x_{22} & \cdots & x_{2m} \\ \cdots & \cdots & \cdots & \cdots \\ x_{n1} & x_{n2} & \cdots & x_{nm} \end{bmatrix} \qquad (i = 1,2,\dots,n; c = 1,2,\dots,m) \tag{1}$$

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Where x_{ij} indicates the performance of the i^{th} alternative with respect to the j^{th} criteria.

Step 2: for this decision matrix to be dimensionless and all its elements to be comparable, it must be "normalized".

$$P_{ij} = \frac{x_{ic}}{\sum_{i=1}^{n} x_{ic}} \quad (2)$$

$$P_{ij} = \frac{1/x_{ic}}{\sum_{i=1}^{n} 1/x_{ic}} \quad (3)$$

Where P_{ij} is the normalized value of x_{ij}.

For beneficial criteria requiring higher values, can be selected by equation (2). While for non-beneficial criteria where lower values are preferred, equation (3). Within the automation process, a series of functions will be integrated that will allow the program to identify which of the two scenarios will be used for each particular data.[16]

Step 3: using the AHP (Analytic Hierarchy Process) or Shannon's Entropy Method[17] the priority weights or, also called, the relative importance of all the criteria determined for the case are determined (w_j).

Therefore, the relative weight w_{cr} from criteria C_c=(c=1,2,…,m) with respect to the benchmark C_r is calculated using equation 4.

$$w_{cr} = \frac{w_c}{w_r} \quad (4)$$

Where w_r is the weighting (weight) of the reference criterion? Normally, the reference criterion is chosen according to the one with the highest weighting.

The use of w_{cr} allows all pairs of differences between performance measures to be translated into the same dimension, i.e., that of the benchmark.

Step 4: the degree of mastery of the alternative is calculated Ai on the alternative A_j using equation (5)

$$\delta(A_i, A_j) = \sum_{c=1}^{m} \emptyset_c (A_i, A_j) \quad \forall(i,j) \quad (5)$$

In the above equation, the degree of mastery of the alternative A_i in front of the alternative A_j which is represented by $\emptyset_c$ (A_i,A_j) in relation to the criterion Cc=(c=1,2,…,m) and is evaluated by equation (6).

$$\emptyset_c (A_i, A_j) = \begin{cases} \sqrt{\frac{w_{cr}(P_{ic} - P_{jc})}{\sum_{c=1}^{m} w_{cr}}} & \text{if } (P_{ic} - P_{jc}) > 0 \\ 0 & \text{if } (P_{ic} - P_{jc}) = 0 \\ -1/\theta \sqrt{\frac{(\sum_{c=1}^{m} w_{cr})(P_{ic} - P_{jc})}{w_{cr}}} & \text{if } (P_{ic} - P_{jc}) < 0 \end{cases} \quad (6)$$

Where:

- P_{ic} and P_{jc} are the performance of the alternatives A_i and A_j, respectively in relation to c.
- θ is the loss damping factor.
- $\emptyset_c$ (A_i,A_j) indicates the contribution fraction of the criterion c to function δ(A_i,A_j), while comparing the i^{th} alternative with each alternative j^{th}.[18]

When the result (P_{ic}-P_{jc})>0 is obtained it represents a benefit or gain for the function δ(A_i,A_j); On the other hand, when (P_{ic}-P_{jc})=0 the value 0 is assigned to $\emptyset_c$ (A_i,A_j); and when (P_{ic}-P_{jc})<0, a loss of the alternative is indicated i^th on the alternative j^{th}.

Step 5: subsequently, the degree of global mastery of the alternative is determined A_i (ζ_i) using the following equation:

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$$\zeta_i = \frac{\sum_{j=1}^{n} \delta(A_i, A_j) - \min \sum_{j=1}^{n} \delta(A_i, A_j)}{\max \sum_{j=1}^{n} \delta(A_i, A_j) - \min \sum_{j=1}^{n} \delta(A_i, A_j)} \quad (7)$$

Finally, the alternatives are ranked in descending order according to their overall values and the alternative with the overall degree of dominance (ζ_i) highest is selected as the best.

METHOD

Proposed Solution

The project will develop a web application that will automate the TODIM method process (an acronym in Portuguese for "Interactive and Multicriteria Decision Making"). The user will enter, either manually or through an Excel file, a matrix with the values of the alternatives and criteria to be evaluated. It will be developed using the programming language Python, HTML and JavaScript.[19]

Because of this concept, for the development of the TODIM Method automation project, we have chosen to use the DIMMA strategy: Design and Implementation Methodology for Metaheuristic Algorithms.[20]

Implementation of DIMMA

As a critical point, it is essential to understand that tactics considered 'metaheuristics' are strategies that guide the search process. The goal in these cases is to efficiently explore the search space to find solutions that are as close to optimal as possible. Metaheuristic algorithms are approximate and usually non-deterministic.

The DIMMA strategy provides guidelines for anyone who wants to design and implement a metaheuristic algorithm and includes several phases, steps, disciplines, and principles for designing and implementing a specific metaheuristic strategy for a given optimization problem. In the case of the present project, it will be used to automate the TODIM Method since it is a 'MCDM (Multicriteria decision making)' method.[20]

DIMMA Phases

Following the principle of metaheuristic problems, the TODIM method is based on a design that allows finding optimal solutions and that is independent of the problem's design. In other words, although it has few application cases, TODIM has metaheuristic characteristics that would allow the implementation of DIMMA in the development of an application that automates its process.

For the correct implementation of DIMMA in project development, there are three sequential phases, each with its own steps. These phases can be visualized with their expected level of effort in figure 2: Initiation, Plan, and Construction.

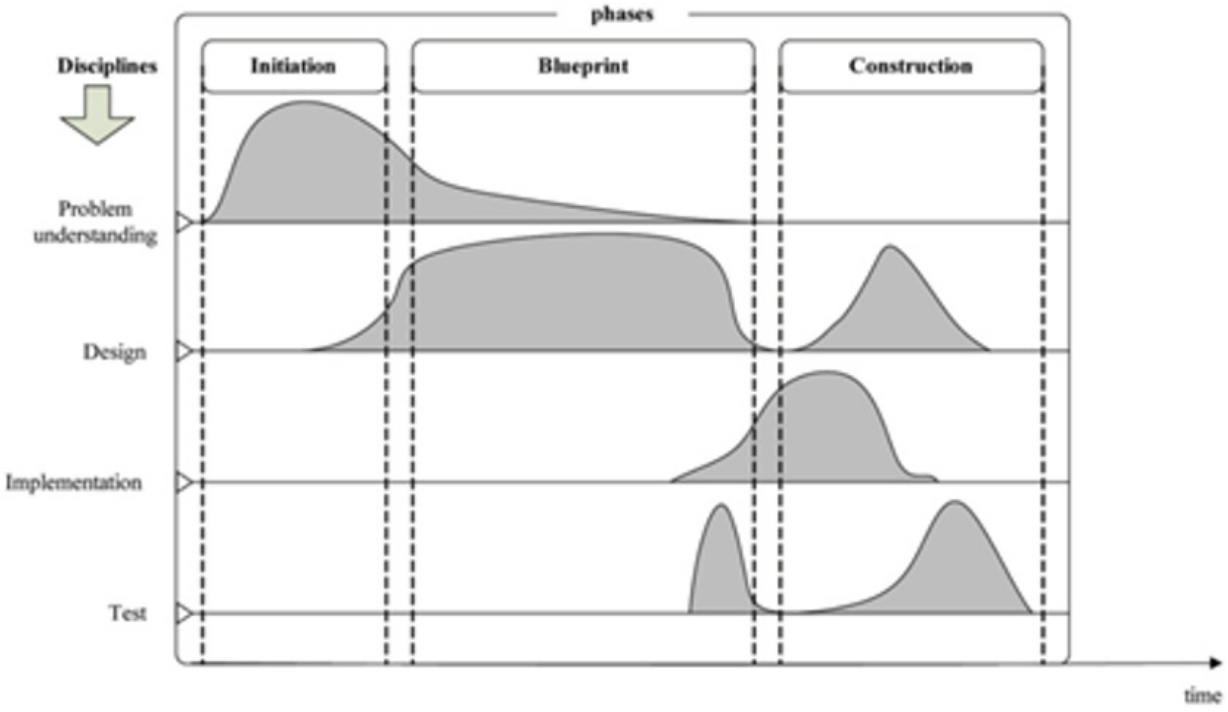

Figure 2. DIMMA Phases and Level of Effort

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In each step of the phases, different activities are defined, which must be performed in order to successfully complete each step in its corresponding phase.[21] The steps that make up each phase can be visualized in the figure 3.

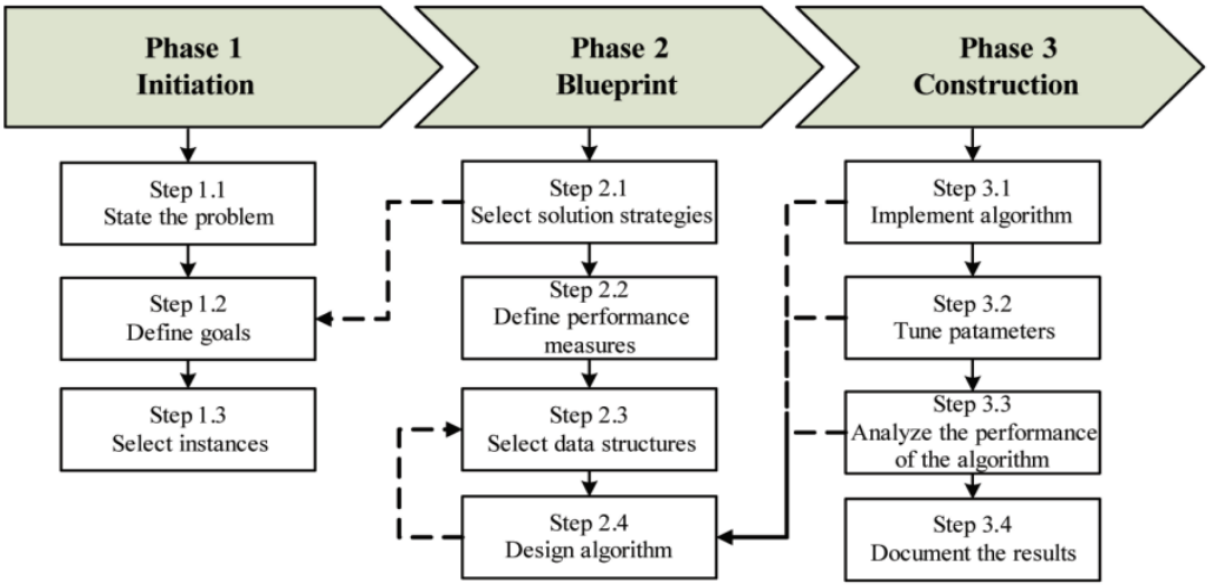

Figure 3. DIMMA Steps and Phases

Phase 1: Initiation

It consists of a problem statement, in which the problem at hand must be precisely understood and the design objective clearly defined. And, as can be seen in the figure 3, consists of three steps or activities that must be completed.

- Raising the issue.
- Define objectives.
- Select instances.

For the first task, it is important not only to define the problem in a simple sentence, but also to present mathematical expressions that state the problem in question. In the TODIM method, we can find different equations that define the whole process, with all stages of the methodology being defined from equation (1) to equation (7).

In this project, the main objective will be to automate this mathematical procedure. It will be tested through inputs and outputs based on the document defining the TODIM method for the first time.[15]

Therefore, as clarified above, any variations or modifications to the methodology that have subsequently arisen will not be taken into account for the purpose of this project.

Phase 2: Blueprint

The Plan phase has as its most important objectives the selection and definition of performance measures, as well as the design of an algorithm for the solution strategy that's planned to be implemented. The steps/ tasks that make up this phase are:

- Select solution strategy.
- Define performance measures.
- Selecting data structures.
- Design algorithm.

In the development of the application, the strategy defined in the TODIM Method will be used. Whereas, in order to define a performance measure, usually in DIMMA, the main factors taken into account are time and quality of the solutions. In this case, given that we will be using a specific application case, we will choose to take as a performance measure the quality of the 'Outputs' that the program gives when evaluating the alternatives entered.

For the data structure, the code will use arrays that can store the data entered through Excel spreadsheets. In the same way, such a way of structuring the entered and processed data can be exported by the user in the same spreadsheet format.

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Phase 3: Construction

The final phase consists of implementing the previously designed algorithm, adjusting the parameters, analyzing its performance and, finally, documenting the results. Therefore, it may be necessary to review previous steps and their respective steps to justify and/or improve the decisions made within the algorithm.

For example, if a performance test is required, the algorithm could be modified based on the results obtained. Such a dynamic within the third phase can be reflected in figure 3. DIMMA Steps and Phases.

The steps that make up this phase are:

- Implementation of the Algorithm.
- Adjust parameters.
- Analyze the performance of the Algorithm.
- Documenting results.

For the automation of the TODIM method as a web application, we have chosen to use the Python programming language, HTML and JavaScript supported by tools such as Visual Studio Code, Python Flask and Virtual Environment, among other resource packages to implement different functions in the web application.

In the current case, we have already a series of strict steps defined through the TODIM method, so the algorithm will work based on the research resulting in the presentation work of this technique of evaluation of alternatives (TODIM). Therefore, its performance will be based on other case studies performed by other authors but based on the same method.

Through the figure 4 an example of an algorithm of the TODIM process can be seen. From the evaluation of the information received to the determination of weights and, finally, the ranking of the alternatives.[22]

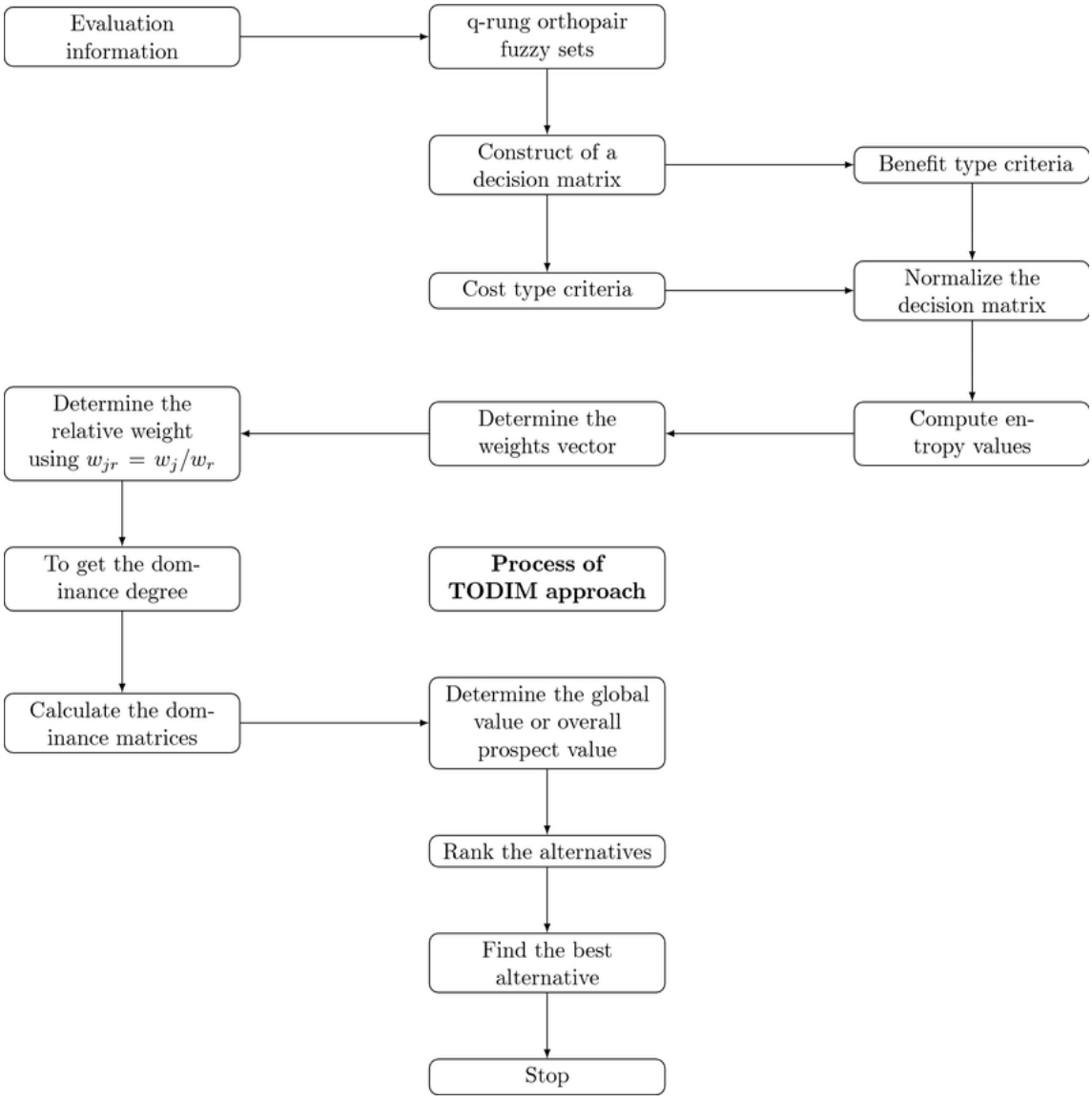

Figure 4. TODIM Algorithm and Process

RESULTS

This document has presented the information researched for the complete understanding of TODIM as a methodology for the evaluation of multi-criteria alternatives. The research itself has allowed the design of the back and front-end operation of the web application for the automation of TODIM. In this sense, it can be assured that the choice of the programming languages Python, HTML and JavaScript for the external and internal design of the coding of the TODIM methodology has been focused on creating an environment that contains only the elements useful for the user.

Particularly, and as already mentioned throughout the document, it is expected that the main beneficiaries of the use of the application will be students, professors and any other type of investigation type personnel who are interested in applying TODIM to the evaluation of alternatives.

For this purpose, Auto-TODIM has been designed as an intuitive web application that allows the user to visualize step by step the data generated by the methodology and export them to an Excel compatible format (.xlsx or CSV) for use or storage.

Figure 5. Auto-TODIM environment

Auto-TODIM Operation

The application starts by displaying the default blank menu displaying a series of buttons at the top and bottom of the screen. In the first banner, titled on screen as “Subir archivo .xlsx” the user is asked to start running the application by entering the input matrix.

Main Banner

As can be seen in figure 7, the main banner consists of three buttons that will generate the most important start-up functions when starting to enter data for the first or multiple times.

- Select file: this button will allow the user to select an “.xlsx” format file to enter the input matrix.
- Upload: allows you to load the matrix stored in the selected file into the application.
- Restart: by pressing this button, the user will be able to reset the screen, and the data loaded in the code, and all the alternatives, criteria, tables and graphs that the user has not previously exported will be lost.

Figure 6. File Selection Window

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Figure 7. Main Banner

Matriz de entrada:

12	32	42	42	123
312	32	32	32	55
46	64	76	13	412
12	32	42	42	77
312	32	32	32	123
12	12	32	312	55
31	312	32	312	313

Figure 8. Input Matrix Loaded

When a file is loaded, if it contains the correct information, a table with the input matrix will be loaded on the screen, which will serve as the basis for implementing the TODIM methodology. It should be noted that the file to be loaded into the application must start entering data from Excel cell A1 and contain only the data of the input matrix, without formatting. This, to guarantee and create a standard when entering data in Auto-TODIM for all users.

Criteria Register

On the second banner on the screen is the criteria registration section, which automatically detects the number of criteria required to apply the TODIM methodology. A menu is displayed in which the user must manually enter the criteria needed to evaluate the alternatives and fill in the necessary data: Type, Name and Weight of each criterion.

Figure 9. Banner Registration Criteria

Also, the user will be able to see on the screen the criteria added to the project and the total sum of the weights of these criteria (figure 10). If necessary, an 'Edit' button will be available to correct any of the data entered erroneously.

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Nombre	Tipo	Peso	Acción
C1	max	0.3200	Editar
C2	min	0.1113	Editar
C3	min	0.3109	Editar
C4	max	0.1233	Editar
C5	min	0.1344	Editar

Suma total de pesos: 0.9999

Figure 10. Table of Criteria Entered

Standardized Decision Matrix

Once the input matrix and criteria have been entered correctly, the user will be able to view the normalized decision matrix on the screen through the use of equations (2) and (3) according to the type of criterion in question.

Matriz de decisión normalizada:

0.0163	0.1376	0.1282	0.0535	0.1141
0.4233	0.1376	0.1682	0.0408	0.2552
0.0624	0.0688	0.0708	0.0166	0.0341
0.0163	0.1376	0.1282	0.0535	0.1823
0.4233	0.1376	0.1682	0.0408	0.1141
0.0163	0.3668	0.1682	0.3975	0.2552
0.0421	0.0141	0.1682	0.3975	0.0449

Figure 11. Normalized Decision Matrix

Dominance Matrices and General Degrees of Dominance.

Matrices de Dominancia:

Matriz de Dominancia para la Alternativa 1:

-0.4071	0.0000	-0.0401	0.0127	-0.1411	-1.1278	0.0000	-0.3589	0.0396	-1.0246	-2.4717
-0.0461	0.0688	0.0573	0.0369	0.0801	-0.3797	0.0875	0.1335	0.0675	0.1037	0.0126
0.0000	0.0000	0.0000	0.0000	-0.0682	0.0000	0.0000	0.0000	0.0000	-0.7122	-0.7122
-0.4071	0.0000	-0.0401	0.0127	0.0000	-1.1278	0.0000	-0.3589	0.0396	0.0000	-1.4471
0.0000	-0.2293	-0.0401	-0.3439	-0.1411	0.0000	-1.4352	-0.3589	-1.6701	-1.0246	-4.4889
-0.0258	0.1235	-0.0401	-0.3439	0.0693	-0.2838	0.1172	-0.3589	-1.6701	0.0965	-2.0991

Suma total de la Matriz de Dominancia 2 para la Alternativa 1: -11.2064

Matriz de Dominancia para la Alternativa 2:

0.4071	0.0000	0.0401	-0.0127	0.1411	0.3609	0.0000	0.1116	-0.3214	0.1377	0.2888
0.3609	0.0688	0.0974	0.0242	0.2212	0.3399	0.0875	0.1740	0.0546	0.1724	0.8284
0.4071	0.0000	0.0401	-0.0127	0.0729	0.3609	0.0000	0.1116	-0.3214	0.0990	0.2501
0.0000	0.0000	0.0000	0.0000	0.1411	0.0000	0.0000	0.0000	0.0000	0.1377	0.1377
0.4071	-0.2293	0.0000	-0.3567	0.0000	0.3609	-1.4352	0.0000	-1.7008	0.0000	-2.7751
0.3813	0.1235	0.0000	-0.3567	0.2104	0.3493	0.1172	0.0000	-1.7008	0.1682	-1.0661

Suma total de la Matriz de Dominancia 2 para la Alternativa 2: -2.3361

Figure 12. Dominance Matrices

https://doi.org/10.56294/dm2025492

While the normalized matrix is generated, the user will be able to see when scrolling down the application screen that multiple dominance matrices have also been generated, one for each alternative. Two tables are displayed on the screen, which show part of the procedure carried out through the equations (4), (5) and (6).

The second table shows the contents of the dominance matrix itself, and at the bottom of the table is the total sum of the results of the dominance of each row. At the same time, each dominance is highlighted in yellow on one side of the matrix.

Finally, the lower part of the screen shows what could be considered as the general results of the TODIM method in the form of a table called "Degrees of General Dominance" where the Total sum of Dominance is displayed $\sum_{j=1}^{n}\delta(A_i,A_j)$, the General Degree of Dominance ζ_i given by equation (7) and the ranking for each alternative, respectively.

MIN: -20.4172

MAX: 0.2605

Grados de Dominancia General:

Alternativa	Suma	Zeta	Rango
A6	0.2605	1.0000	1
A2	-2.3361	0.8744	2
A5	-5.6123	0.7160	3
A4	-9.6498	0.5207	4
A1	-11.2064	0.4454	5
A7	-12.3225	0.3915	6
A3	-20.4172	0.0000	7

Figure 13. Degrees of General Dominance

Auto-TODIM displays all these data, as well as the minimum and maximum overall degree of dominance found among all the alternatives, finally showing the complete information in a table and two graphs that visually represent the Total Sum of Dominance and Overall Degree of Dominance of each alternative.

Also, there are three buttons that allow the user to download/export the results obtained from the multi-criteria alternatives evaluation project using TODIM.

- Descargar Solución (Excel): download the complete project, except for the graphs, in Excel spreadsheet format (.xlsx).
- Descargar Solución (CSV): download the complete project, except for the graphs, in CSV format.
- Descargar Gráficas: allows the user to download in .PNG format the graphs generated on screen of the Total Sum of Dominance and General Sum of each Alternative.

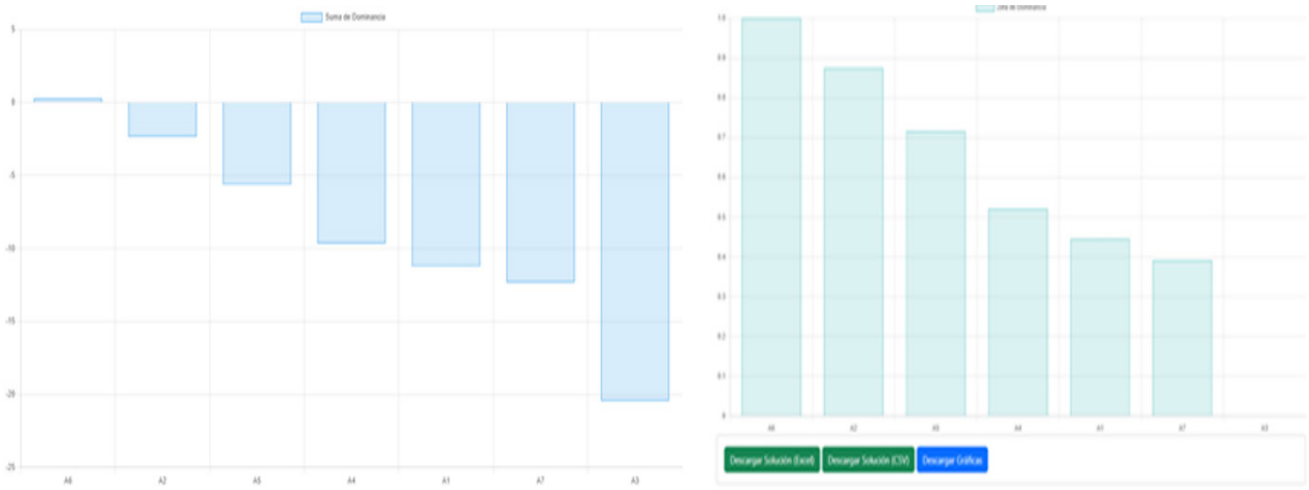

Figure 14. Graphics and Download Buttons

https://doi.org/10.56294/dm2025492

	A	B	C	D	E	F
1	Grados de Dominancia General:					
2	Alternativa	Suma	Zeta	Rango		
3	A6	0.2605	1.0000	1		
4	A2	-2.3361	0.8744	2		
5	A5	-5.6123	0.7160	3		
6	A4	-9.6498	0.5207	4		
7	A1	-11.2064	0.4454	5		
8	A7	-12.3225	0.3915	6		
9	A3	-20.4172	0.0000	7		
10						
11						
12	MIN:	-20.4172				
13	MAX:	0.2605				
14						

Figure 15. TODIM Scenario Case Study Excel Export

CONCLUSIONS

Application development has become an essential part of industries. When working on multiple projects, a team may see the results of their research hampered by the overload of projects they are put in charge of, or they may seek to streamline the procedure of evaluating multi-criteria alternatives by automating the process in question.

Auto-TODIM not only seeks to implement the TODIM methodology in the virtual environment but also offers users of multiple indoles (professional or educational) an efficient option to evaluate the alternatives of their projects in short periods. Through the development of this application, software has been obtained that can obtain results that are consistent with the projects evaluated in other proposals of the same TODIM model.

For example, Shankar and Abkishek's work in "Application of TODIM (TOmada de Decisao Interativa Multicriterio) method for under-construction housing project selection in Kolkata" 3 presents a case that was used as a test base in the development of the application.

However, the images shown in the previous section's illustrations are a completely hypothetical case. In this case, the TODIM method is employed for evaluating and selecting the most appropriate and affordable unfinished residential property in the city of Kolkata. Here, 14 alternative housing projects are considered, which are scattered all over the city.

Those housing projects are evaluated using ten critical criteria, chosen after taking valuable opinions from the concerned developers/clients/domain experts. Therefore, Kolkata's decision matrix for this under-construction housing project selection problem consists of 14 alternatives and 10 evaluation criteria, as shown in the input matrix 3. Through Auto-TODIM, it has been possible to generate a hypothetical example that complies with the same steps and procedures used in the Kolkata housing project. As can be seen in the hypothetical case presented in the previous section, Auto-TODIM has generated a project that can be exported and displayed on screen without problems.

Recommendations

In an overall view, the present project completed the main objective. Auto-TODIM is a web application that allows to the users evaluate and rank different alternatives with multi-criteria using the TODIM method. Even with this main objective completed, in future updates or versions, the interface and back-end code can be improved to automize the process in a more efficient way.

For example:

- Add buttons to allow the user to upload criteria in a same or different excel file with the Input Matrix.
- In an internal database or files, save and organize different projects of evaluation.
- Improve the format of data stored in spreadsheets when exporting projects.

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The authors declare that there is no conflict of interest.

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