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Heuristic computation using hybrid PMP-Greedy and AHP model for categorization and measurement of a framework aligned to ISO/IEC 90003:2014

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Abstract.
The ISO/IEC 90003:2014 standard oriented to the application of quality management in software development processes, requires a structured evaluation that considers technical and organizational criteria. Its purpose is to support organizations that develop or maintain software to implement an effective quality management system using the structure and requirements of ISO 9001:2008, specifically adapted to software-related activities. This article proposes a hybrid heuristic computational model based on the PMP-Greedy (Positional Major Mean Weight) and AHP (Analytic Hierarchy Process) methods to assign weights to the categories that make up a framework aligned to ISO/IEC 90003:2014 that allows companies engaged in software development to measure the degree of compliance with the standard, as well as, to assess conformance and non-conformance to achieve certification to the standard.
Keywords: Positional Major Mean Weight (PMP), hierarchical analysis process (AHP), ISO/IEC 90003:2014 standard

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1 Introduction

The efficient management of software projects in consulting companies represents a strategic challenge, particularly when seeking to align with quality standards such as ISO/IEC 90003:2014. This standard provides guidelines for the implementation of a quality management system based on ISO 9001:2018, specifically focused on the software lifecycle. However, in dynamic environments with multiple competing projects, robust approaches are required for prioritization, evaluation and selection of initiatives to ensure regulatory compliance and optimization of resources.

In this context, ISO/IEC 90003:2014 provides fundamental guidelines for adapting the principles of ISO 9001:2008 to the software environment, establishing criteria for ensuring quality in the software development, maintenance and delivery lifecycle. However, its implementation requires analytical tools to measure the degree of compliance in a structured manner.

Heuristic computation emerges as an effective strategy to face multi-criteria decision problems in which the exact solution is computationally expensive or not feasible. In this context, the AHP (Analytic Hierarchy Process) method allows structuring complex decisions by means of hierarchies and paired comparison matrices, generating relative weights for each criterion. The PMP-Greedy approach is based on ordering and selecting categories according to their relative performance in each criterion, averaging their position to obtain a composite measure and prioritizing them efficiently.

The use of heuristic techniques such as AHP (Analytic Hierarchy Process) and PMP-Greedy (Positional Maximum Mean Weight) allows building models that weight criteria, hierarchize options and offer optimal results when the solution space is large or complex. This paper develops a hybrid model that integrates both mathematical approaches to measure the degree of compliance with the standard, as well as to evaluate conformance and non-conformance to achieve certification.

2 Materials and methods

2.1 AHP Method (Analytic Hierarchy Process)

According to Sánchez (2022), Triantaphyllou (2000) and Forman(2001), the Analytic Hierarchy Process (AHP) was developed during the 1970s at the University of Pennsylvania by Dr. Thomas L. Saaty, when he sought to develop a formal instrument for the evaluation and selection of alternatives, which had the characteristics of being solid in its mathematical foundations, useful in decision making and simple in its application. Saaty (2008) considers that in order to solve a problem, the decision-maker goes through three stages: he starts with the formulation of the problem, then performs an evaluation and finally selects the best course of action that contributes most to the achievement of the objective. The stages consist of:

1. Criteria definition:

$$C = \{c_1, c_2, ..., c_n\}. \quad (1)$$

Given a set of n criteria $C_1, C_2, ..., C_n$, a pairwise comparison matrix $A \in \mathbb{R}^{nxn}$ is constructed, where A[i][j] represents the relative importance of criterion C_i with respect to criterion C_j. Properties:

$$a_{ii} = 1, a_{ji} = 1 / a_{ij}. \quad (2)$$

2. A comparison matrix $A = [a_{ij}]$ is constructed, where a_{ij} represents the relative importance of criterion c_i versus c_j. The system A - w = λ_max - w is solved, where λ_max is the largest eigenvalue of A.

3. The Saaty (2008) scale (1 to 9) is used to evaluate comparisons, see table 1.

Table 1. Saaty Scale

Value	Meaning	Interpretation
1	Equal importance	Both criteria contribute equally
3	Moderate importance	Slight preference for one over the other
5	Strong importance	Strong preference for one over the other
7	Very strong	Importance Clear and proven dominance
9	Extreme importance	Absolute evidence of superiority
2,4,6,8	Intermediate values	Used when there is compromise between judgments

4.- Each column of the matrix is normalized and the rows are averaged to obtain the vector of weights:

$$W = [w_1, w_2, ..., w_n]. \quad (3)$$

5.- Consistency check:

5.1.- λ_{aax} = mean of the ratios between A-W and W:

$$CI = (\lambda_{aax} - n)/(n - 1). \quad (4)$$

$$CR = CI / RI \quad (5)$$

(RI: Random Index according to n)

5.2.- If CR < 0.1, the matrix is consistent.

2.2 PMP-Greedy heuristic method

According to ANSI/IEEE Std 100-1984 (American National Standards Institute / Institute of Electrical and Electronic Engineers), heuristics deals with exploratory methods or algorithms during the resolution of complex problems in which solutions are discovered by evaluating the progress achieved in the search for a final result. For Jiménez (2002) the heuristic method Greedy, Major Positional Mean Weight PMP, is designed with the purpose of finding an acceptable solution, but in a fast way. Normally this solution obtained will be used as an initial solution in improvement heuristics. It follows an iterative process; in each iteration a decision is made. That decision is the assignment of one of the possible candidates, which is a local optimum. This results in assigning a value to a variable that will make the value of the objective function, in the case of a minimization, minimum and vice versa. This decision is irrevocable and once this value has been assigned it will not be removed, for this reason they are also known as "myopic algorithms", referring to the fact that they "do not see beyond" the current solution. The same process is then repeated until a value has been assigned to each variable, which results in the value of the objective function being obtained quickly, but not optimally. In cases where there are a large number of variables, its proximity to the optimal solution becomes less as the number of variables increases. In short, this algorithm assigns the variables that are best at any given time and not globally. The pseudocode of the generic Greedy method is presented below, where C is the space in which the solutions are contained and the set of possible solutions S ⊆ C. Given a finite set of elements or candidates:

$$S=\{s_1, s_2,..., s_n\}. \tag{6}$$

and a matrix of evaluations or positional weights:

$$W=[w_{ij}] \in \mathbb{R}^{mxn} \tag{7}$$

where:

- w_{ij} represents the weight of the element if at position j,
- n is the number of elements,
- m is the number of evaluated positions or criteria.

The objective is to construct an ordered solution π (a permutation of the set S) such that the weighted average of the positional weights is maximum:

$$\max \pi \in P(S)\ PMP(\pi). \tag{8}$$

where:

$$PMP(\pi)= \frac{1}{n} \sum_1^n W\pi(i), i\ . \tag{9}$$

The weight of the element located at position i according to the permutation π is taken, and its average is calculated. The evaluation matrix of the PMP method accepts cardinal or ordinal values representing the performance of an alternative with respect to a criterion. A direct numerical scale is generally used, see table 2, as follows:

Table 2. PMP Scale

Value	Meaning (Performance)
1	Very low
2	Low
3	Slightly low
4	Acceptable
5	Average or moderate
6	Slightly good
7	Good
8	Very good
9	Excellent (optimum performance)

2.3. PMP-Greedy (Positional Maximum Mean Weight) and AHP (Analytic Hierarchy Process) method

In multi-criteria decision-making contexts (Blum & Roli, 2020), the integration of quantitative techniques makes it possible to capture both the hierarchical structure of the problem and the rational weighting of alternatives. The AHP (Analytic Hierarchy Process), proposed by Saaty (1980), allows prioritizing criteria through paired comparisons, and the PMP (Positional Mean Weight Greedy) evaluates alternatives through a heuristic based on the positional order of performance on multiple criteria. The stages consist of:

1.- Start from an evaluation matrix:

$$D = [d_{ij}]. \quad \textbf{(10)}$$

for Alternatives:

$$A = \{A_1, ..., A_n\}. \quad \textbf{(11)}$$

and criteria:

$$C = \{c_1, ..., c_n\}. \quad \textbf{(12)}$$

2.- For each criterion c_j the subsections are ordered value d_{ij} and ranks r_{ij} are assigned.

3.- The PMP of an alternative is defined as:

$$PMP(A_i) = (1/m) * \Sigma (1 / r_{ij}) \quad \textbf{(13)}$$

where $r_{ij} \geq 1$ and lower is better

4.- Construct the evaluation matrix $E \in \mathbb{R}^{mxn}$, where e_{ij} represents the performance of alternative i under criterion j.

5.- Construct the AHP comparison matrix $A \in \mathbb{R}^{mxn}$ for the criteria and calculate the vector of weights $w \in \mathbb{R}^{mxn}$. Construct the weighted PMP matrix:

$$M=E \cdot w. \quad \textbf{(14)}$$

7.- Apply the PMP (Greedy) method, given a vector of weighted scores $S= [s_1, s_2,...,s_n]$:

$$S_i(\%) = (S_i / \sum S_i) \times 100 \quad \textbf{(15)}$$

This provides a vector of percentages that sums to 100, indicating the relative proportion of each alternative.

2.4. ISO/IEC 90003:2014

ISO/IEC 90003 (ISO, 2014) is a standard derived from ISO 9001, dedicated to the software engineering quality development process, covering the acquisition, supply, development, operation and maintenance of software, and support services. The application of ISO/IEC 90003 is appropriate in software that: is part of a commercial contract with another organization, is a product available in the market, is used as a support process of an organization, is part of a hardware, or is related to software services. ISO 90003 are the standards used for the development, supply and maintenance of software. The application areas are related to: Information Systems Development, Life Cycle Processes and Software Quality. The standard seeks to provide guidance in situations where the demonstration of a supplier's ability to develop, supply and maintain software products is required. The standard suggests control classes and methods for the production of software that satisfies the established requirements.

ISO 90003 serves to interpret ISO 9001 in the field of Software Engineering. In fact, the name is: "Guide for the application of ISO 9001 for the development, implementation and maintenance of software." ISO 90003 is required by all software development companies to: Meet customer expectations, Obtain quality benefits. ISO 90003 serves to interpret the ISO 9001 standard in the field of Software Engineering. In fact, the name is: "Guide for the application of ISO 9001 for the development, implementation and maintenance of software." ISO 90003 is required by all software development companies to: Meet customer expectations, obtain quality benefits, and to reduce production costs. The sections of ISO/IEC ISO90003 (ISO, 2014) that are related to the measurement model are, see table 3.

Table 3. ISO/IEC Std. 90003:2014

Area	Requirement
4.- Quality management system	4.1.- General requirements 4.2.- Documentation requirements
5.- Management responsibility	5.1.- Management Commitment 5.2.- Customer focus 5.3.- Quality policy 5.4.- Planning 5.5.- Responsibility, audit and communication 5.6.- Management Reviews
6.- Resource management	6.1.-Provision of resources 6.2.- Human resources 6.3.- Infrastructure 6.4.- Work Environment
7.- Product realization	7.1.- Product Realization Planning 7.2.- Customer processes 7.3.- Design and development 7.4.- Purchasing 7.5.- Production and provision of service 7.6.- Control of monitoring and measuring devices
8.- Measurement, analysis and improvemer	8.1.- General 8.2.- Monitoring and Measurement 8.3.- Control of non-conforming product 8.4.- Data analysis 8.5.- Improvement

3 Results

ISO/IEC 90003:2014 is a standard derived from ISO 9001, dedicated to the software engineering quality development process, covering the acquisition, supply, development, operation and maintenance of software, and support services. The standard suggests control classes and methods for the production of software that satisfies the established requirements. The sections of ISO/IEC ISO90003:2014 that relate to the software quality framework and measurement model are: 4.- Quality management system, 5.- Management responsibility, 6.- Resource management, 7.- Product realization and 8.- Measurement, analysis and improvement. To categorize and measure each of the sections of the ISO 90003:2014 standard, as well as the conformity and non-conformity for certification, the following algorithm derived from the AHP and PMP-Greedy integration is followed:

Algorithm: AHP + PMP

```
START
 DEFINE function load_matrix_ahp(file)
IF file ends in ".csv" THEN
        READ CSV file without header and convert to array.
    BUT
        READ Excel file with header and index column.
        CONVERT data to numeric array (float)
    RETURN AHP matrix
 END FUNCTION
 DEFINE function load_matrix_pmp(file)
    IF file ends in ".csv" THEN
        READ CSV file
    BUT
```

```
  14.        READ Excel file
  15.     OBTAIN list of alternatives from the
first column.
  16.     GET list of criteria of the headings,
except the first column.
  17.     EXTORT numerical evaluation matrix
  18.     RETURN criteria, alternatives and PMP
matrix
  END FUNCTION

  20. DEFINE file paths:
  21. file_ahp ← "template_matrix_ahp.xlsx"
  22. file_pmp_file ← "template_pmp_matrix.xlsx"

  23. LOAD matrix_ahp using
load_matrix_ahp(file_ahp).
  24. LOAD criteria, alternatives, matrix_pmp
using load_matrix_pmp(file_pmp)

  25. CHECK if all values of matrix_ahp are
finite
  26. IF NOT FINITE THEN
  27. DISPLAY error message: "Invalid AHP
matrix" 28.
  28. IF YES
  29.     CALCULATE eigenvalues and eigenvectors
of array_ahp
  30.     IDENTIFY index of largest real
eigenvalue
  31.     OBTAIN vector of weights from the
corresponding eigenvector.
  32. NORMALIZE weights by dividing them by
their sum.
  33. SHOW "Normalized AHP weights:"
  34.     FOR each criterion and its
corresponding weight
  35. SHOW criteria and weights to 3 decimal
places.
  36.     END FOR
  37.     CALCULATE raw scores: matrix_pmp ·
weights
  38. NORMALIZE scores: (score / total sum) ×
100
  39. DISPLAY "Normalized Scores (PMP + AHP):"
  40. FOR each alternative and its score
  41. DISPLAY alternative and its score in
percentage
  42. END FOR
  43.     CREATE Excel sheet with:
  44.         - AHP Matrix
  45.         - PMP Matrix
  46.         - Results with raw score and
percentage
  47. SAVE file "Results_AHP_PMP.xlsx.xlsx".

  48. DISPLAY message: "Results exported".
  49. END
```

The tables generated with the heuristic method integrated with AHP allow to generate the weights (w) that are related to the sections of the standard, thus establishing the frame of reference and the measurement model, finally, the result is the following table of weights, see table 4.

Table 4. Table of Weights with AHP + PMP

Section	Subpart	Weight(w)	Total Weight (%)
4 Quality Management System	4.1 General Requirements	0.5	15
	4.2 Documentation Requirements	0.2	
	4.3 Quality Manual	critic	
	4.4 Document Control	0.3	
	4.5 Critical Logging	critic	
5 Management Commitment	5.1 Management Commitment	0.3	15
	5.2 Customer focus	0.06	
	5.3 Quality Policy	0.24	
	5.4 Responsibility, authority and communication	0.4	
6 Resource management	6.1 Resource management	1	10
7 Product realization	7.1 Product realization planning	0.2	50
	7.2 Customer-Related Processes	0.2	
	7.3 Design and Development	0.25	
	7.4 Purchasing	0.15	
	7.5 Production and Service Provision	0.15	
	7.6. Control of Measurement Monitoring Devices	0.05	
8 Measurements Analysis and Improvement	8.1. General critical	critic	10
	8.2. Monitoring and Measurement	0.4	
	8.3. Control of Non-Conforming Product	0.3	
	8.4 Data Analysis	0.2	
	8.5 Improvement	0.1	

The results shown below are related to the measurement made to a consulting firm in the state of Mexico dedicated to the development of software products and artifacts following a software development life cycle and methodology. The results are categorized in the following sections, see table 5.

Table 5. Categorization of results

Section	% Section	Total
4.1	45.71	86.64
4.2		
4.3		
4.4		
4.5		
5.1	83	
5.2		
5.3		
5.4		
6	83.33	
7.1	98	
7.2		
7.3		
7.4		
7.5		
7.6		
8.1	100	
8.2		
8.3		
8.4		
8.5		

The ISO/IEC 90003:2014 certification process verifies that an organization's software development and maintenance processes fully comply with the requirements of the standard. The certification service is organized by the International Organization for Standardization (ISO) through a worldwide network of certification services that are authorized through accreditation bodies and certification bodies. Each accreditation body is authorized by ISO to license other professional organizations as certification bodies. Certification bodies, the number of which may vary by country, conduct the actual certification audits and certify qualifying organizations. The percentage of the section reflects the degree of compliance of the point of the standard, for example, section 4, Quality Management System, has a degree of compliance of 45.71%. The degree of compliance of the standard is 86.64%. The integrated counts for each section are essential for the measurement verdict, see table 6. The result of the Measurement allows the consulting company to obtain information regarding the degree of compliance with ISO/IEC 90003:2014 and whether it is possible to achieve certification.

Table 6. Verdict

Result	
All Critical Questions Met	Yes
Number of NCMs found:	6
Verdict:	Not certified

The verdict reflects that the company must address the nonconformities found in the software lifecycle process adopted to produce the software artifacts or products.

4 Discussion

The international standard ISO/IEC 90003 was developed for the application of ISO 9001 to computer software. In other words, ISO/IEC 90003 presents the implementation of the general quality management methodology of the ISO 9001 standards, which deals with product development, product production and product services and maintenance, for the special case of software development and maintenance. Both ISO 9001 and ISO/IEC 90003 are separately reviewed and updated once every 5-8 years. The current international standard ISO/IEC 90003:2014 (ISO/IEC, 2014) is an application of ISO 9001:2008 to computer software. The ISO/IEC 90003 international standard is intended to serve the entire population of software development and maintenance organizations by adopting a policy of standard completeness and redundancy.

The integration of AHP and PMP methods offers a robust solution for multi-criteria decision making, combining the structural rigor of hierarchical analysis with the efficiency of a heuristic approach. This hybrid approach responds to the need for decision processes that are both structured and justified and operationally agile, especially in environments with multiple alternatives and heterogeneous criteria. The proposed integration allows the use of AHP-derived weights as weights in the positional aggregation of the PMP, thus achieving a weighted, coherent and hierarchical evaluation. The AHP-PMP integration contributes to the field of multi-criteria decision making by hybridizing qualitative and quantitative techniques under a practical and accessible approach. It represents a flexible methodology that can be easily implemented on computational platforms (Python, Excel), which democratizes its application even in organizations with limited resources. Moreover, by employing a percentage normalization of results, the model facilitates the interpretation of the scores and enables the comparison between alternatives in an intuitive way, promoting transparent and justifiable decision making. These features facilitate the achievement of a universality that allows ISO/IEC 90003 to fit the immense variety of organizations belonging to the software industry and is especially suited to serve as a tool for evaluating and certifying organizations in the software industry.

The integration of AHP and PMP brings robustness to the evaluation of compliance with standards such as ISO/IEC 90003. It allows you to structure strategic priorities using AHP and accurately assess compliance using PMP. This hybrid model is ideal for organizations seeking objectivity, repeatability and traceability in their internal and external audits.

5 Conclusions

The combination of Greedy with AHP improves the selection of alternatives in combinatorial optimization problems. While Greedy focuses on fast and efficient decisions, AHP introduces an analytical process based on weighted criteria, which reduces the probability of making suboptimal decisions due to purely local evaluation. Greedy is known for its fast problem solving, but it does not always guarantee the global optimal solution.

The inclusion of AHP allows refining the selection strategy, ensuring that local choices are more representative of the overall problem. This is key in applications where real-time computation and output efficiency are equally important. While combining AHP with Greedy offers advantages in solution quality, it also introduces computational overhead due to the computation of comparison matrices in AHP. However, this overhead is justifiable in problems where solution quality is more important than speed of execution. The integration of the Greedy method with AHP represents a hybrid strategy that balances computational efficiency with more informed decision making. Its application to combinatorial optimization problems and intelligent systems demonstrates that the Greedy heuristic can benefit from an analytical framework such as AHP to obtain solutions more closely aligned with quality criteria and operational constraints.

The methodological integration between the Analytical Hierarchical Process (AHP) and the Greedy method by Positional Mean Weight (PMP) represents a robust tool to address complex multi-criteria evaluation problems, such as the ISO/IEC 90003:2014 conformance assessment, which applies quality management to software development, delivery and maintenance. In this context, AHP makes it possible to rank the requirements of the standard according to their strategic, operational or compliance relevance, establishing objective weights by means of expert judgments. Subsequently, PMP facilitates the positional evaluation of different units or processes against these criteria, allowing prioritization based on a structured and quantitative analysis.

References

Ballestero, E. (1998). *Metodología multicriterio en las decisiones empresariales*. McGraw-Hill.

Blum, C., & Roli, A. (2003). Metaheuristics in combinatorial optimization: Overview and conceptual comparison. *ACM Computing Surveys, 35*(3), 268–308. https://doi.org/10.1145/937503.937505

Forman, E. H., & Gass, S. I. (2001). The analytic hierarchy process—An exposition. *Operations Research, 49*(4), 469–486. https://doi.org/10.1287/opre.49.4.469.11231

ISO. (2014). *ISO/IEC 90003:2014: Software engineering — Guidelines for the application of ISO 9001:2008 to computer software*. International Organization for Standardization.

Jiménez, A., & Ríos-Insua, S. (2005). Una visión del proceso de toma de decisiones multicriterio: El caso del proceso analítico jerárquico. *Revista de Estadística y Sociedad, 45*(2), 3–11.

Jiménez, M. (2002). *El proceso analítico jerárquico: Fundamentos, metodología y aplicaciones*. McGraw-Hill.

Saaty, T. L. (1980). *The analytic hierarchy process*. McGraw-Hill.

Saaty, T. L. (2008). Decision making with the analytic hierarchy process. *International Journal of Services Sciences, 1*(1), 83–98. https://doi.org/10.1504/IJSSCI.2008.017590

Sánchez, G. (2022). *Técnicas heurísticas para la planeación*. Fundación ICA.

Triantaphyllou, E. (2000). *Multi-criteria decision making methods: A comparative study*. Springer. https://doi.org/10.1007/978-1-4757-3157-6