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Neutrosophic Model for Prioritizing Preventive Maintenance

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Abstract

This article focuses on a key challenge within the field of information and communication technologies (ICT): how to accurately establish preventive maintenance needs to ensure their optimal functioning. The research aims to answer the question of how to identify and prioritize such needs in an environment where uncertainty and unpredictability play a crucial role. To address this issue, we employ a neutrosophic method, an innovative approach that integrates indeterminacy into the analysis. Although numerous studies have explored ICT maintenance, few have considered the ambiguity inherent in data and expert opinions, leaving a gap that this work seeks to fill with a more flexible and realistic perspective. The relevance of this topic becomes evident in a world increasingly dependent on ICT, where technical failures can cause costly interruptions or compromise essential services. Therefore, understanding and anticipating preventive maintenance demands is vital. The study employs the neutrosophic method to collect and analyze expert assessments, revealing key patterns regarding intervention priorities in these systems. The findings show that this technique allows for the detection of critical needs more effectively than conventional approaches. In terms of contributions, the work not only enriches theory by offering a robust framework for dealing with uncertainty but also provides practical solutions applicable to daily ICT management, thus promoting their long-term reliability and efficiency.

Keywords: Neutrosophic Method; Preventive Maintenance; ICT; Uncertainty; Needs; Information Technology; Prioritization.

1 | Introduction

Decision-making, especially in real-world contexts, often involves complexities that go beyond simple linear logic. We are often faced with situations where the available choices present a series of conflicting criteria. This is a dilemma often described in the classic Indonesian proverb "buah simalakama" (if eaten, the father dies, if not eaten, a mother dies): whatever choice is made, there are always unpleasant consequences. This paper attempts to examine the problem of decision-making from the perspective of conflicting criteria.

In their daily lives, people constantly turn to Information and Communication Technologies (ICTs) to carry out their professional duties, tools that cover everything related to the transfer, management, and digital storage of data [1-3]. This intensive use has allowed for the progressive integration of social processes, making them indispensable for modern administrative management, to the point that today it is unimaginable to operate without their support [4-6]. However, this dependence, arising from the continuous use of ICTs, has made essential human activities closely linked to their proper performance [7]. Therefore, ensuring that these

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technologies function smoothly has become a crucial priority for today's society. To prolong the durability of technological resources, technological maintenance has been incorporated [8-10], an engineering practice that uses instruments, computer equipment, and specialized software to optimize their performance [11, 12]. Depending on the type of technology and its application, specific strategies have been established to prevent failures before they occur [13].

The International Standards Organization, through the ISO 9001:2008 standard, has laid the foundations for organizations to integrate technological maintenance as part of their quality culture, defining essential guidelines for its execution [14-16]. Each entity designs its maintenance management system, thus contributing to the continuity of the services it offers without interrupting its administrative operations [11, 17]. Determining when and how to intervene technologically poses a decision challenge that can be addressed through neutrosophic logic, an approach that models maintenance needs with a triplet M (T, I, F): T reflects the values that justify the intervention, I indicates the level of uncertainty where no action is required, and F represents the degree to which the need is nonexistent. Faced with this situation, the research aims to develop a method based on neutrosophic numbers to specify preventive maintenance demands in ICTs, offering an innovative solution that considers the ambiguity and complexity inherent in this type of analysis.

2 | Preliminaries

To raise the comprehension of the main concepts associated with the investigation the present section provides an overview of the topic's references. A description of Information Technologies is provided, and an overview is introduced. of Preventive maintenance as a necessary element of the Technologies of Information. Finally, maintenance is represented using neutrosophic numbers in uncertainty modeling.

2.1 | Information Technologies

The Technologies of Information have been conceptualized as the integration and convergence of computing microelectronics, telecommunications, and the technique for the processing of data, its main com - components are: the human factor, the contents of the information, the equipment, infrastructure material, software, and the mechanisms electronic exchange of information, the elements of politics and regulations and financial resources [18].

ICTs are defined as technological devices made up of hardware and software that allow editing, producing, storing, exchanging, and conveying data between different systems of information with common protocols [19]. The ICTs integrate media of computer science, telecommunications, and networks, making possible communication and interpersonal collaboration multidirectional [20]. Introduce change in the management of organizations and provide new functions where administrative control represents one aspect of these [21].

Ensuring the correct technological functioning in an organization constitutes a task of considerable importance, of the correct operation of the technology depends on the profitability and efficiency of the organization. Therefore, technology maintenance is an administrative process that requires the necessary attention.

2.2 | Preventive Maintenance

Maintenance is defined by the Royal Spanish Academy as the set of operations and care necessary for facilities, buildings, industries, and technologies to continue functioning properly [22]. Each asset or medium has distinctive characteristics that make it unique from the others, however, they all have a cycle of life [23, 24]. Figure 1 shows an illustration of the cycle of life of media technology.

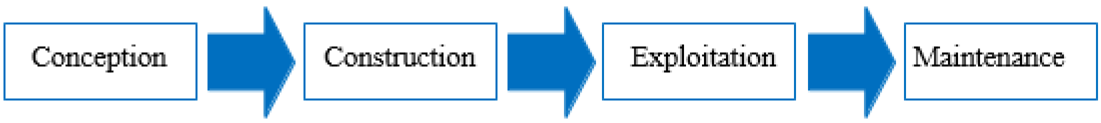

Figure 1. A cycle of life of the media technology.

Preventive maintenance prevents potential problems and reduces the occurrence of sudden failures. Maintenance must be budgeted in advance and involves a financial investment that is contracted and planned. Doing maintenance to the computer of the system minimizes the shocks so much economic since new investments should be made estimated and known with greater precision.

The importance of preventive technological maintenance is that allows you to determine whether it is being misused computer equipment and if it is warning of possible failures.

Advantages of the maintenance computer scientist preventive:

- Low-cost forehead to the interventions unexpected corrective measures.
- Reduction of the risk of failures.
- Reduce the probability of stops unforeseen.
- Allows plan investments, because it anticipates he failed.

2.3 | Representation of the Maintenance Process Through Neutrosophic Numbers

The section presents the structure of the operation of the method to determine the need for preventive maintenance of Information Technologies. The operation is guided by a three-activity workflow [25]. The method bases its operation on a neutrosophic environment on the linguistic decision analysis scheme that can address criteria of different natures and provide linguistic results in a neutrosophic setting [1, 26]. Figure 2 shows the workflow of the proposed method.

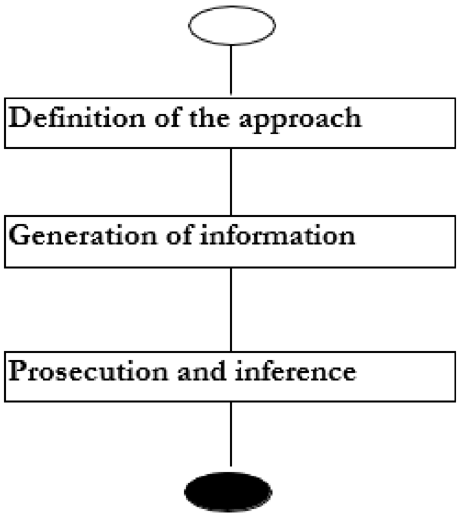

Figure 2. Representation of the method.

The method is designed to bear the flow of work and to determine the needs for Information Technology maintenance. It consists of the following activities: defining the approach, generating information, and processing and inference. The different stages of the method are described below:

1. Definition of the approach

In this stage, the evaluation framework is defined to correct the structure on the needs of the maintenance. The framework is modeled from the following elements:

- Be $E = \{e1, , en \}$, $(n > 2)$ a set of experts.
- Be $TI = \{ti1, tim\}$, $(m > 2)$ a set of Technologies of the Information.
- Be $C = \{c_1, , c_k \}$, $(k > 2)$ a set of criteria that characterize technologies.

HE uses a frame of information heterogeneous [27]. Each expert can wear a domain different numeric or linguistic to evaluate each criterion, taking into account its nature in a neutrosophic environment [28, 29]. From the modeling of the elements that define the approach, the information is generated.

2. Generation of information

By defining the framework, we obtain the knowledge of the set of experts. For each expert, their preferences are provided using utility vectors. The utility vector is expressed by Eq. (1):

$$P^i_j = \{p^i_{j1_1}, , p^i_{jh}\} \quad (1)$$

Where :

P^i represents the preference granted on criterion $c\,k$ about the technologies r_j voiced by the expert.

The stage obtains the information that is necessary for the processing of inferences, from the set of data obtained through the consultation with the experts, they perform the processing and the inference of the information to obtain recommendations on maintenance needs.

3. Prosecution and inference

The processing and inference stage is responsible for carrying out a collective linguistic evaluation based on the established framework with the data set obtained, which can be interpreted by Information Technology engineers. To achieve this, the information is unified and added [30, 31].

From the processing, a process of ordering alternatives is carried out, which are prioritized to deal with heterogeneous information and provide linguistic results.

To 2TLNNS is defined as [32, 33]:

To leave of $S = S = \{s0, \ldots, sg\}$ that represents a 2TLSs with cardinality odd t + 1.

It is defined for $(St, a), (Si, b), (Sf, c) \in L$ and a, b, c ∈ [0, t], where $(St, a), (Si, b), (Sf, c) \in L$ They independently express the degree of truth, degree of indeterminacy, and degree of falsity by 2TLSs.

For this reason, so much: 2TLNNSs HE defines:

$$lj = \{(St, a), (Si, b), (Sf, c)\} \quad (2)$$

Where :

$$0 \leq \Delta^{-1}(Stj, a) \leq t, 0 \leq \Delta^{-1}(Sij, b) \leq t, 0 \leq \Delta^{-1}(Sfj, c) \leq t$$

$$0 \leq \Delta^{-1}(Stj, a) + 0 \leq \Delta^{-1}(Sij, b) + 0 \leq \Delta^{-1}(Sfj, c) \leq 3t$$

Through the function of punctuation and precision, HE classifies 2TLNN [34]. Let

$$l1 = \{(St1, a), (Si1, b), (Sf1, c)\}\, a$$

2 TLNN in The L the function of punctuation and precision in l_1 he defines as:

$\Delta^{-1}((l1)) \in [0, t]$

$$S(l1) = \Delta\left\{\frac{2t + \Delta{-1}(St1,a) - \Delta{-1}(Si1,a) - \Delta{-1}(Sf1,a)}{3}\right\} \quad \Delta^{-1}((l1)) \in [0,t]$$

$$H(l1) = \Delta\left\{\frac{t + \Delta{-1}(St1,a) - \Delta{-1}(Sf1,a)}{2}\right\} \quad \Delta^{-1}(h(l1)) \in [0,t]$$

Unification of the information:

The information is unified in a specific linguistic domain ($_T$). Numerical information is transformed into the linguistic domain ($_T$) by following these steps:

i). Select a domain linguistic specific, called a set of terms linguistic basics (T).

ii). Transformation of values numerical in [0, 1] to the (T).

iii). Transformation of fuzzy in 2-tuple linguistic.

iv). Aggregation of information:

The aggregation allows the unification of the information for it which develops through two steps to calculate a global evaluation of the technologies.

The operator of the aggregation unifies the different weights expressed for each expert [35], taking into account your knowledge and its importance in the Information Technology maintenance process.

Assessment of the equipment

The final step in the process of prioritization is to establish a classification between the Technologies of the Information, this classification allows to classify the technologies with more value and postpone or reject the maintenance of other technologies to make the process more effective.

The technology of the information further criticism is that that has the assessment collective maximum Max $\{(r\ l, (a\ j), = 1{,}2\ , , n\}$. The requirements are prioritized according to this worth in order to decrease.

3 | Implementations of the Method for Determining Preventive Maintenance Needs

This section describes the operation of the proposed method. A case study was conducted at a company to determine the maintenance needs of the available technology. The example illustrates the method's applicability.

Development of the activity 1: Frame evaluation

For the present study of the case, they identified a frame of job compound by:

E = { e1, … , and 4}, which represent the 4 experts who intervened in the process. Those who carry out the evaluation:

TI = { TI 1, …, TI 3}, of 3 technologies of the Information From the assessment of the

C = { c 1, …, c 5} which make up the 5 criteria evaluative. Table 1 shows the criteria used.

Table 1. Criteria used for the assessment of the ICTs.

No	Criterion	Description
1	Time of exploitation	Represents the amount of hours averages that he me-God is used in the activity of labor
2	Failures	Considers the presence of failures or defects before the scheduled maintenance time
3	Performance	Variation of the operation of the technology before of the application of the maintenance
4	Conditions environmental	Represents the characteristics of the around geographic in that HE frames the organization (Sea, height, humidity, etc.)
5	Air conditioning	Conditions suitable of temperature for he co - right operation of the technological medium

Each expert could provide information numerically or linguistically, depending on the nature of the criteria. A common linguistic domain is chosen to verbalize the results expressed in Figure 3.

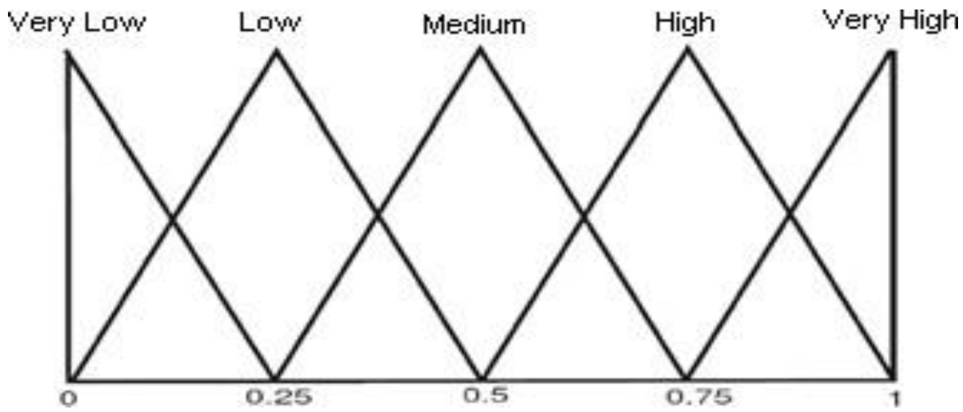

Figure 3. Domain of Selection S $_T$.

For the values numerical, will use the scale linguistics followed by numbers neutrosophics of worth-only proposals in Table 2 [31, 35].

Table 2. Linguistic terms employees.

Linguistic term	**SVN Numbers**
Extremely good (EB)	(1,0,0)
Very very good (MMB)	(0.9, 0.1, 0.1)
Very good (MB)	(0.8,0.15,0.20)
Good (B)	(0.70,0.25,0.30)
Moderately good (MDB)	(0.60,0.35,0.40)
Media (M)	(0.50,0.50,0.50)
Moderately poor (MDP)	(0.40,0.65,0.60)
Bad (MA)	(0.30,0.75,0.70)
Very bad (MM)	(0.20,0.85,0.80)
Very very bad (MMM)	(0.10,0.90,0.90)
Extremely bad (EM)	(0,1,1)

Development of the activity 2: Generation of information

From the information obtained on Information Technologies, it is stored for later processing. Evaluation framework is presented in Table 3. The evaluation criteria are carried out on the ST scale.

Table 3. Presentation of the results.

		e 1			**e 2**			**e 3**			**e 4**	
c 1	(0.9, 0.1, 0.2)	(0.8, 0.1, 0.3)	(0.5, 0.2, 0.4)	(0.6, 0.3, 0.2)	(0.7, 0.3, 0.1)	(0.8, 0.1, 0.2)	(0.9, 0.2, 0.1)	(0.6, 0.2, 0.2)	(0.5, 0.3, 0.3)	(0.6, 0.2, 0.2)	(0.5, 0.4, 0.1)	(0.3, 0.3, 0.2)
c 2	(0.6, 0.2, 0.2)	(0.5, 0.4, 0.1)	(0.3, 0.3, 0.2)	(0.9, 0.1, 0.2)	(0.8, 0.1, 0.3)	(0.5, 0.1, 0.4)	(0.6, 0.3, 0.2)	(0.7, 0.3, 0.1)	(0.8, 0.1, 0.2)	(0.9, 0.2, 0.1)	(0.6, 0.2, 0.2)	(0.5, 0.3, 0.3)
c 3	(0.9, 0.2, 0.1)	(0.6, 0.2, 0.2)	(0.5, 0.3, 0.3)	(0.6, 0.2, 0.2)	(0.5, 0.4, 0.1)	(0.3, 0.3, 0.2)	(0.9, 0.1, 0.2)	(0.8, 0.1, 0.3)	(0.5, 0.1, 0.4)	(0.6, 0.3, 0.2)	(0.7, 0.3, 0.1)	(0.8, 0.1, 0.2)
c 4	(0.6, 0.3, 0.2)	(0.7, 0.3, 0.1)	(0.8, 0.1, 0.2)	(0.9, 0.2, 0.1)	(0.6, 0.2, 0.2)	(0.5, 0.3, 0.3)	(0.6, 0.2, 0.2)	(0.5, 0.4, 0.1)	(0.3, 0.3, 0.2)	(0.9, 0.1, 0.2)	(0.8, 0.1, 0.3)	(0.5, 0.1, 0.4)
c 5	(0.9, 0.1, 0.2)	(0.9, 0.1, 0.2)	(0.9, 0.1, 0.2)	(0.6, 0.3, 0.2)	(0.7, 0.3, 0.1)	(0.9, 0.2, 0.1)	(0.6, 0.2, 0.2)	(0.5, 0.3, 0.3)	(0.9, 0.1, 0.2)	(0.6, 0.2, 0.2)	(0.5, 0.4, 0.1)	(0.3, 0.3, 0.2)

The information HE transforms for unify the information heterogeneous. The games diffuse later about ST HE transform in 2-tuples linguistic.

TO from the aggregation process an evaluation was calculated collective of Information Technologies. For process of aggregation used the average weighing of the numbers linguistic neutrosophic of 2 tuples. 2-TLNNWA from the data referred to by for each expert [19]. In this case the weighting vectors W = (0.6,0.3,0.2).

Table 4. Prosecution of the result of the data.

		e_1			e_2			e_3			e_4	
c_1	<(S3, 0.2),(S2,0), (S1,1)>	<(S3,0.3),(S2, 0), (S1,1) >	<(S 3.0. 1),(S2.0), (S1, 3)>	<(S3 ,0.4), (S2, 0), (S1, 0)>	<(S 3.0. 0),(S2.0), (S1, 2)>	<(S3, 0.5),(S2,0), (S1,3)>	<(S3, 0.0),(S2,0) , (S1.0)>	<(S3, 0.0),(S2,0), (S1.0)>	<(S3, 0.0),(S2,0), (S1.0)>	<(S3, 0.0),(S2,0), (S1.0)>	<(S3, 0.0),(S2,0), (S1.0)>	<(S3,0. 0),(S2, 0), (S1,0) >
c_2	<(S3, 0.0),(S2,0), (S1.0)>	<(S3,0. 0),(S2, 0), (S1,0) >	<(S 3.0. 0),(S2.0), (S1, 0)>	<(S3 ,0.2), (S2, 0), (S1, 1)>	<(S 3.0. 3),(S2.0), (S1, 1)>	<(S3, 0.1),(S2,0), (S1,3)>	<(S3, 0.4),(S2,0) , (S1.0)>	<(S3, 0.0),(S2,0), (S1,2)>	<(S3, 0.5),(S2,0), (S1,3)>	<(S3, 0.0),(S2,0), (S1.0)>	<(S3, 0.0),(S2,0), (S1.0)>	<(S3,0. 0),(S2, 0), (S1,0) >
c_3	<(S3, 0.0),(S2,0), (S1.0)>	<(S3,0. 0),(S2,0) , (S1,0) >	<(S 3.0. 0),(S2.0), (S1, 0)>	<(S3 ,0.0), (S2, 0), (S1, 0)>	<(S 3.0. 0),(S2.0), (S1, 0)>	<(S3, 0.0),(S2,0), (S1.0)>	<(S3, 0.2),(S2,0) , (S1,1)>	<(S3, 0.3),(S2,0), (S1,1)>	<(S3, 0.1),(S2,0), (S1,3)>	<(S3, 0.4),(S2,0), (S1.0)>	<(S3, 0.0),(S2,0), (S1,2)>	<(S3,0. 5),(S2, 0), (S1,3) >
c_4	<(S3, 0.8),(S2,2), (S1.5)>	<(S3,0. 0),(S2, 0), (S1,2) >	<(S 3.0. 5),(S2.0), (S1, 3)>	(S3, 0.8), (S2, 2), (S1, 5)>	<(S 3.0. 0),(S2.0), (S1, 0)>	<(S3, 0.0),(S2,0), (S1.0)>	(S3.0 .8),(S 2,2), (S1.5)>	<(S3, 0.0),(S2,0), (S1.0)>	<(S3, 0.0),(S2,0), (S1.0)>	(S3 ,0 . 8),(S 2,2), (S1.5)>>	<(S3, 0.3),(S2,0), (S1,1)>	<(S3,0. 1),(S2, 0), (S1,3) >
c_5	<(S3, 0.0),(S2,0), (S1.0)>	<(S3,0. 0),(S2, 0), (S1,0) >	<(S 3.0. 0),(S2.0), (S1, 0)>	<(S3 ,0.4), (S2, 0), (S1, 0)>	<(S 3.0. 0),(S2.0), (S1, 2)>	<(S3, 0.5),(S2,0), (S1,3)>	<(S3, 0.0),(S2,0) , (S1.0)>	<(S3, 0.0),(S2,0), (S1.0)>	<(S3, 0.0),(S2,0), (S1.0)>	<(S3, 0.0),(S2,0), (S1.0)>	<(S3, 0.0),(S2,0), (S1.0)>	<(S3,0. 0),(S2, 0), (S1,0) >

To calculate the collective evaluation, the 2-TLNNWA operator uses the weight vector V = [0.8, 0.2, 0.5] from Table 3.

Table 5. Assessment collective for_each equipment.

<(S3,0.7), (S2,25), (S1,46)>	e2
<(S3,0.9),(S2,4), (S1,6)>	e3
<(S3,0.8),(S2,2), (S1,5)>	e1

Finally, we sort all the collective evaluations and establish a ranking among the teams to identify the best-calculated scoring functions.

Table 6. Results of the function of punctuation.

<(S3,0.8),(S2,2), (S1,5)>	e1
<(S3,0.7),(S2,25), (S1,46)>	e2
<(S3,0.9),(S2,4), (S1,6)>	e3

In this study of the case, the classification It's like: $e_1 < e_2 < e_3$

4 | Conclusions

To meet their assigned objectives, organizations need to ensure that their information technology (IT) systems are reliable and ready to respond to business demands. To reduce the consequences of potential failures, it is essential to implement strategies that support the identification and prioritization of necessary IT maintenance tasks, thereby streamlining decision-making. This research designed an innovative approach to detecting IT maintenance needs, incorporating linguistic expressions that simplify their interpretation and use. This method was tested through an illustrative case study, demonstrating its effectiveness. The results show that this proposal constitutes a robust option and is applicable in real-world environments.

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Author Contribution

All authors contributed equally to this work.

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Data Availability

The datasets generated during and/or analyzed during the current study are not publicly available due to the privacy-preserving nature of the data but are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare that there is no conflict of interest in the research.

Ethical Approval

This article does not contain any studies with human participants or animals performed by any of the authors.

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