Neutrosophic Sets and Systems

Volume 34 *Special Issue: Social Neutrosophy in Latin America*

Article 7

6-1-2020

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Neutrosophic Sets and Systems
{*Special Issue:* Social Neutrosophy in Latin America}, Vol. 34, 2020

University of New Mexico

Neutrosophic Decision Map for critical success factors prioritization in a museum of religious Art

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Abstract: Visits to museums represent a way of keeping culture in memory of new generations. Getting to know the details that characterize each muse logical installation is a fundamental task for workers in the sector. That is why, depending on the knowledge that people have about the place, room recommendations are a problem of decision-making that are currently addressed. The present investigation proposes a method for the recommendation of museum rooms through the use of Neutrosophic Cognitive Map. A case study is applied where the proposal for the recommendation of rooms of the religious art museum of La Concepción in Riobamba is implemented.

Keywords: method; cognitive neutrophic map; museum; recommendations.

1 Introduction

Culture represents an important part that characterizes people. Museums allow you to recreate in a pleasant way the culture of the peoples [1]. Nowadays museums are the fundamental way of conserving historical heritage [2].

Introducing from young ages the curiosity of young people to know the elements that characterize the culture of the peoples is the essence to revive history. Latin America is the second most valued region in the world to visit its cultural heritage.

In Ecuador there are numerous museums that protect an incalculable cultural heritage [3]. In the province of Chimborazo we find several museums, in the city of Riobamba the museum that stands out is the Mothers Concepts museum considered one of the best museums of religious art for the quality and value of the works it has [4].

Knowing what route to take, what room to travel, with what elements to recreate, currently represents a problem of decision-making that visitors face. The problem described above is modeled through the set of previous knowledge that visitors have about the place, the expectations and learning needs they have, among other elements.

The present investigation proposes a method for the recommendation of museum rooms and bases its operation on Neutrosophic Cognitive Map to represent the causal knowledge.

2 Preliminaries

The investigation begins in this section with the main theoretical references on the problem that is addressed. The museums are presented and subsequently the Mothers Concepts museum in Riobamba is characterized. The Neutrosophical Cognitive Maps are characterized for research development. In addition, the theory of Neutrosophical numbers is presented as part of the development of the present investigation.

2.1 Museums

A museum is a permanent, non-profit institution, at the service of society and open to the public, which acquires, preserves, studies, exposes and disseminates the material and intangible heritage of humanity for the purpose of study, education and recreation.

There are numerous categories of museums with their corresponding subcategories, but these are the most common:

Anthropological: they are museums whose pieces and contents deal with the biological and social aspects of human beings, highlighting cultural diversity.

Archeological: they are museums dedicated to the dissemination of archeology and whose collection comes mostly from excavations. If the museum is next to the archaeological site of origin of its collection it is a site museum.

Of Architecture: they are museums whose contents are dedicated to study the constructive processes, their creators and the buildings designed by them. His exhibition is based on the exhibition of construction projects and materials that is models, plans and photographs.

Of Contemporary Art: they are museums whose works and contents have a chronology that includes from the end of the 19th century to the present.

Of Decorative Arts: they are museums whose works and contents are dedicated to those arts destined to produce functional and ornamental objects, such as goldsmithing, embroidery, glass, ceramics or furniture

Of Fine Arts: they are museums dedicated to the different artistic disciplines, and whose collections are formed mainly by painting and sculpture.

Natural Sciences: they are museums dedicated to the knowledge of the diversity of the natural world and among its collections are, among other things, samples of flora, fauna and geological.

Scientific-Technological: they are museums whose objects and contents serve as instruments of study and dissemination of science among society. They are usually quite intuitive and contain objects that can be manipulated and interactive installations.

Ethnographic: they are museums whose objects and contents deal with folklore and the popular uses and customs of a society.

Historical: they are museums whose contents are dedicated to spreading the general history of a specific city or territory to help understand the events that took place there.

Maritime and naval: they are museums whose objects and contents deal with navigation and everything related to the sea.

Military: they are museums whose objects and contents are associated with the army or military events.

Musical: they are museums whose objects and contents are associated with music and its historical evolution. Within this there are several typologies: museums of musical instruments, houses museums of composers, museums associated with opera houses, museums of popular music.

2.2 Characteristics of the Mothers Concepts museum in Riobamba

The religious art museum of the Conceptas de Riobamba, established in 1980 and remodeled in 1997, is one of the jewels of the culture, history and religious tradition of the old and new Riobamba.

It is composed of a set of rooms that are distributed as follows:

Living room 1: Angels: in this room the angels Gabriel, Rafael among others is exposed, being the symbol of evangelization in the 16th century.

Living room 2. Nativity: urns are exhibited with the birth of the child Jesus, demonstrating the great imagination and devotion of the people.

Living room. Pedro: normal size images that were used for processions are displayed and at the same time the denial to Pedro is shown.

Living room 4. Easter week: This room shows the customs and the great respect that people have for Easter or senior week.

Living room 5 and 6. Crucifixes: in this room different crucifixes made by a sculptor passionate about religion are exhibited.

Living room 7. Trinity: there are several pieces of sculpture some of them are covered with gold and silver.

Living room 8. Mary: Here are paintings from the colonial era that still exist today.

Living room 9. Coronation: there are several representations about the transition of the virgin.

Living room 10. Mass and Holiness: In this room we will find several models of oil paintings on canvas, wooden sculptures, polychrome and with silver.

Living room 11. Furniture: Here are objects made with leather, figures with relief, the special thing about this room are the locals.

Living room 12. Daily life: This room is a vivid representation of how cloister nuns usually live.

Living room 13. Wood and ceramic: there are decorated and carved objects that only preserved wealthy people.

Living room 14. Treasures: In this room the most outstanding custodians of the 17th and 18th century is exposed.

2.3 Neutrosophic Cognitive Map

The causative models: there are different kinds of causality which are expressed in forms of graphics, where each causative model that is represented by a graphic is representations of the causality among concepts. The causative models allow modeling the cause or effect of any determined event [5], [6], [7],[8].

The original definition of truth value in neutrosophical logic is shown as referred to as N $\{(T,\mathrm{I},\mathrm{F}):T,I,F \subseteq [0,1]\}$ n, in which:

T: represents the degree of belonging,
I: the degree of undefined,
F: the falsehood.

What represents a neutrosophics valuation, considered as a mapping of a group of propositional formulas to N, and for each sentence p to obtain the result by equation 1 [9], [10], [11].

$$v(p) = (T, I, F) \tag{1}$$

The Cognitive neutrosophics Map: is a technique which allows the representations of the causative relations of different concepts as an extension of mental models using extended values or numbers in a interval of [-1,1] [12], [13], [14], [15]. The MCN are presented by extended model with feedback to show causality.

There are three possible kinds of causative relations among concepts in the MCN [16], [17]:

$W_{ij} > 0$: It refers a positive causality among concepts. It means, the increasing or decreasing in the value of C_i, It goes on increasing or decreasing in the value of C_j.

$W_{ij} < 0$: It refers a negative causality among concepts in the value of C_i, which takes to a decreasing or increasing of the value of C_j.

$W_{ij} = 0$: It refers to no existence of the relations among concepts C_i and C_j.

2 Method for critical success factors prioritization in a museum

The method is structured to support the process of recommending museum rooms. It bases its operation through a multi-expert multicriteria approach where room recommendations are modeled based on the set of criteria. The causative models are used in the inference as a way of representing the knowledge, beginning by the artificial technique of the Cognitive Neutrosophic Map.

The figure 1 shows the schema of the suggested method. The system is designed by an architecture of three layers for modeling the suggested business entries, processing and exits.

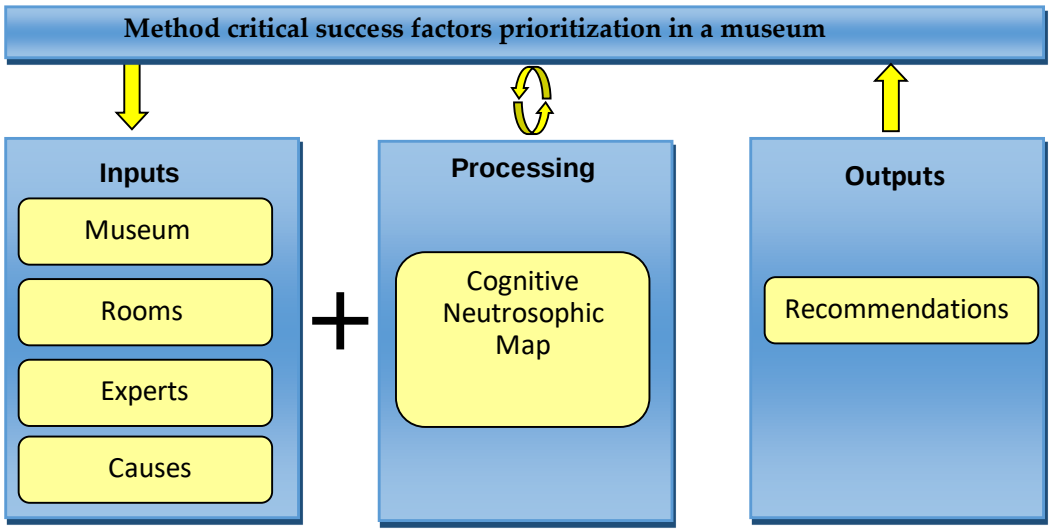

Figure 1. Method critical success factors prioritization in a museum

The outputs of the system: they represent the results of the processing where the recommendations associated with the decision-making problem are obtained.

The process is made by means of the flow of works which are the five activities of the core of the proposed method. The figure 2 shows the schema with the method workflow.

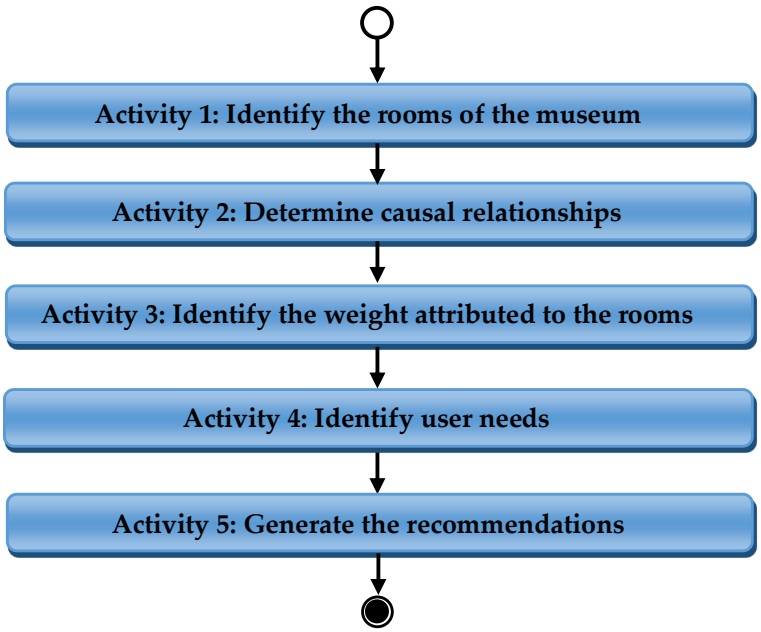

Figura 2. Scheme with the method workflow.

The method for the recommendation of museum rooms is made up of five activities as expressed in figure 2. A description of each of the proposed activities is given below.

Activity 1: Identification of museum rooms.

The identification of the museum rooms represents the activity in which the general set of criteria that represent the basis of the inference are determined. A multicriteria approach is used, thus identifying the greatest possible criteria attributed to each room.

Activity 2. Determination of causal relationships:

Activity 2 Bringing about the causative relations by means of a multiple-expert criteria`s view. It guarantees the causative knowledge of criteria. The activity consists in extracting the knowledge that experts have about the rooms. The causative relations are expressed by means of a group of values which represent the relations of direct

or inverse implications. It is used the scale suggested by Perez shown in the table 1[18].

Table 1. The group of values to express causality

Number of value	Impact
1	(NMF) negatively greatest strongly
-0,75	(NF) negatively strong
-0,50	(NM) negatively medium
-0,25	(ND) negatively weak
0	without importance
0,25	(PD) positively weak
0,50	(PM) positively médium
0,75	(PF) positively strong
1	(PMF) positively strongest

During the determination of the causative relations is made a process of adding where the results is called adjacent matrix which represent the values assigned to the arches[19], [20]. So:

$$M = \begin{bmatrix} \cdot\cdot & \cdot\cdot & \cdot\cdot \\ \cdot\cdot & W_{ij} & \cdot\cdot \\ \cdot\cdot & \cdot\cdot & \cdot\cdot \\ \cdot\cdot & \cdot\cdot & \cdot\cdot \end{bmatrix}$$

The adjacent matrix $M = M(C_i C_j)$ represent the causative value of the arch function, the node C_i which is C_j increases. Causatively C_j if $M_{ij} = -1$, and when the node C is not C if $M_{ij} = 0$.

Activity 3: Identification of the weights attributed to the rooms.

Beginning by getting the adjacent matrix from the activity 2, the added value emited by the group of expert are all together the relations with the weight of the nodes in which are generated the cognitive neutrosophic map as result [21], [22], [23],[24].

By means of a static analysis of the result of the value gotten in the adjacent matrix can be calculated the grade of exit using the equation 1 where are the attributed weight for each manifestation.

$$id_i = \sum_{i=1}^{n} \left\| I_{ji} \right\| \tag{1}$$

Activity 4: Identification of user needs.

The identification of the needs of the users consists in determining which elements they wish to recreate during the visit.

Table 2. The group of values to express preference

Number of value	Impacto impact
0	No knowledge about the room
0,25	Light knowledge about the room
0,5	Low knowledge of the room
0,75	Adequate knowledge about the room
1	High knowledge about the room

Activity 5: Generation of room recommendations.

It is the process based in the simulation of the scene suggested by Glykas, the new values of the concepts express the influence of the concepts interconnected to the specific concept and it is calculated by means the following equation 2

$$A_i^{(K+1)} = f\left(A_i^{(K)} \sum_{i=1;\, j\neq i}^{n} A_i^{(K)} * W_{ji}\right) \quad (2)$$

Where:

$A_i^{(K+1)}$: it is the value of the concept C_i in the step k+1 of simulation.

$A_i^{(K)}$: it is the value of the concept C_j in the step K of the simulation.

W_{ji}: It is the weight of the connection which goes from the concept C_j to the concept C_i and f (x) is the activated function [25], [26].

3 Application of the proposed method in critical success factors prioritization in a museum religious Art

From the case analysis it is possible to determine the behavior of the different alternatives based on possible recommendations. For the proposed method, a system for the recommendation of museum rooms is implemented. The implementation of the proposal on a case study is carried out in the religious arts museum of Las Madres Conceptas in Riobamba.
Below, it is described the results of the studies:

Activity 1. Identification of museum rooms:

The identification of museum rooms is conditioned by the case under analysis. A total of 7 rooms are specifically identified. Table 3 presents the rooms used in the decision making problem.

Table 3. Proposal of rooms used.

Node	Concept
C_1	Living room 1: Angels, Nativity
C_2	Living room 2: Pedro, Easter week
C_3	Living room 3: Crucifixes
C_4	Living room 4: Trinity, Mary
C_5	Living room 5 : Coronation, Mass and Holiness
C_6	Living room 6: Furniture, Daily life
C_7	Living room 7: Wood and ceramic, Treasures

Activity 2: Determination of causal relationships.

The scale proposed in Table 1 was used to determine the causal relationships. Three experts from the area of knowledge under study were involved. The 3 aggregating Neutrosophic Cognitive Maps were obtained, containing the answers in a single result.

Table 4 shows the adjacency matrix obtained as a result of the process.

Table 4. The adjacent matrix as the result of the process

	C1T, I, F	**C2 T, I, F**	**C3 T, I, F**	**C4 T, I, F**	**C5 T, I, F**	**C6 T, I, F**	**C7 T, I, F**
C1 T, I, F	[0, 0,0]	[0.75, 0.5,0.25]	[0.5, 0.25,0]	[0.5, 0.25,0]	[0.5, 0.25,0]	[0.5, 0.25,0]	[0.25, 0,0]
C2 T, I, F	[0.75, 0.5,0.25]	[0, 0,0]	[0.75, 0.5,0.25]	[0.75, 0.5,0.25]	[0.75, 0.5,0.25]	[0.75, 0.5,0.25]	[0.75, 0.5,0.25]
C3 T, I, F	[0.5, 0.25,0]	[0.75, 0.5,0.25]	[0, 0,0]	[0.5, 0.25,0]	[0.75, 0.5,0.25]	[0.5, 0.25,0]	[0.5, 0.25,0]
C4 T, I, F	[0.75, 0.5,0.25]	[0.5, 0.25,0]	[0.5, 0.25,0]	[0, 0,0]	[0.5, 0.25,0]	[0.5, 0.25,0]	[0.5, 0.25,0]
C5 T, I, F	[0.5, 0.25,0]	[0.5, 0.25,0]	[0.5, 0.25,0]	[0.5, 0.25,0]	[0, 0,0]	[0.5, 0.25,0]	[0.5, 0.25,0]
C6 T, I, F	[0.5, 0.25,0]	[0.5, 0.25,0]	[0.5, 0.25,0]	[0.5, 0.25,0]	[0.5, 0.25,0]	[0, 0,0]	[0.5, 0.25,0]

	C1T, I, F	**C2 T, I, F**	**C3 T, I, F**	**C4 T, I, F**	**C5 T, I, F**	**C6 T, I, F**	**C7 T, I, F**
C7 T, I, F	[0.25, 0,0]	[0.5, 0.25,0]	[0.5, 0.25,0]	[0.5, 0.25,0]	[0.5, 0.25,0]	[0.5, 0.25,0]	[0, 0,0]

Activity 3: Identification of the weights attributed to the romos.

For the identification of the weights, the knowledge base stored in the adjacency matrix, Table 4, is taken into account, applying the function (1), the behavior of the weight attributed to the manifestations is obtained. Table 5 shows the resulting weights.

Table 5. Weights attributed to each room.

Node	**Concept**	**Weight**
C_1	Living room 1: Angels, Nativity	0,12
C_2	Living room 2: Pedro, Easter week	0,15
C_3	Living room 3: Crucifixes	0,14
C_4	Living room 4: Trinity, Mary	0,13
C_5	Living room 5 : Coronation, Mass and Holiness	0,13
C_6	Living room 6: Furniture, Daily life	0,12
C_7	Living room 7: Wood and ceramic, Treasures	0,12

Activity 4. Identification of user needs:

From the visitor interview, the degree of preference that people have over their knowledge needs was determined through self-assessment. The study was conducted to recommend a visitor under study. Table 6 shows the resulting values. The values are used as activation vectors in the later stage for the recommendation process.

Table 6. Attributed preference to the visiting.

Visitor	**C_1**	**C_2**	**C_3**	**C_4**	**C_5**	**C_6**	**C_7**
A_1	[0.75]	[0.25]	[0.25]	[0.75]	[1]	[1]	[0.75]

Activity 5: Generation of room recommendations.

From the behavior of the weights attributed to the alternatives, the degree of belonging of a room is determined by an aggregation process. Table 7 shows the result of the calculation performed.

Table 7. The attributed weight to the Living room.

Visitor A1	**Weights**	**Preferences**	**Adding**
C_1	0,12	0.75	0,13
C_2	0,15	0.25	0,11
C_3	0,14	0.25	0,14
C_4	0,13	0.75	0,10
C_5	0,13	1	0,09
C_6	0,12	1	0,13
C_7	0,12	0.75	0,09
Index			1,61

Beginning from the simulated process of the scene was obtained the predictions of the behaviour on the visiting

by means of the equation 2.

The prediction models the causal relationships of the rooms and foresees the evolution of these in the visitors.

Figure 3 presents the simulation result showing the different alternatives and their behavior evaluation. From the simulation process, the decision-making problem is solved.

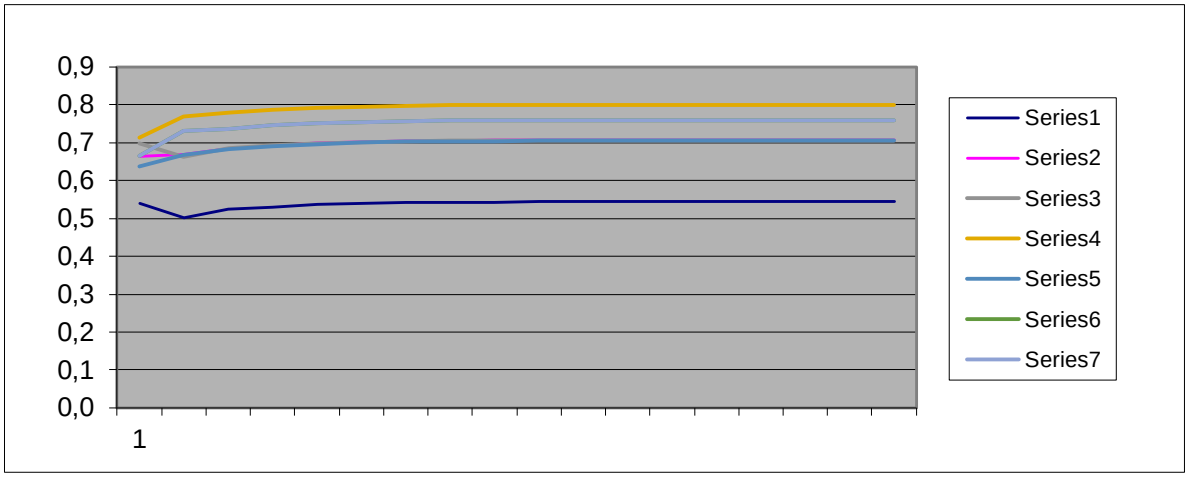

Figure 3. Result of the simulation of scenarios.

In the case of the analyzed study, an order of the alternatives for the recommendations is obtained as follows:

$$R_4 \succ R_7 \succ R_3 \succ R_2 \succ R_5 \succ R_6 \succ R_1$$

From which it is determined that the recommendation issued by the method is:

$$R_4$$

4 Conclusions

From the development of the proposed research, a method was obtained to support decision making on the recommendation of museum rooms. The proposed method is based on a multi-expert multicriteria approach. The inference process is model by neutrosophics numbers.

The implementation of the method made it possible to obtain the added Neutrosophics Cognitive Map with the representation of the causal relationships on the museum rooms under study by identifying the degree of relevance of the visitors.

From the application of the system proposed in the case study it was possible to demonstrate the applicability of the method allowing the recommendation of museum rooms based on the set of criteria that are visitors' preferences.

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Received: October 1st, 2019 Accepted: January 20th, 2020