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Method for Treatment and its Incidence in the Change of Social Rehabilitation Regime using Neutrosophic Compensatory Logic

Eduardo Luciano Hernández Ramos[1], Luis Ramiro Ayala Ayala[2], Diego Fabricio Tixi Torres[3] and Roberto Gonzalez[4]

[1] Universidad Regional Autónoma de los Andes (UNIANDES), Avenida José Lizarzaburo. Riobamba, CP 060150, Chimborazo, Ecuador. Email: ur.eduardohernandez@uniandes.edu.ec
[2] Universidad Regional Autónoma de los Andes (UNIANDES), Avenida José Lizarzaburo. Riobamba, CP 060150, Chimborazo, Ecuador. Email: ur.luisayala@uniandes.edu.ec
[3] Universidad Regional Autónoma de los Andes (UNIANDES), Avenida José Lizarzaburo. Riobamba, CP 060150, Chimborazo, Ecuador. Email: ur.diegotixe@uniandes.edu.ec
[4] Roberto González, Focus, Rosario, Provincia de Santa Fe, Argentina. Email roberto.gonzalez@focus.com.ar

Abstract. Throughout life, people can make mistakes that lead to custodial sentence. When people pay off their debt to society, they join a social rehabilitation regime. Unfortunately, in all cases a complete rehabilitation is not achieved. This research aims to develop a method for the treatment and its impact on changing social rehabilitation regimen. The uncertainty of this process is modeled using compensatory neutrosophic logic. This is an extension of fuzzy compensatory logic to the neutrosophic framework. A case study is implemented from which a group of people undergoing rehabilitation is analyzed to determine their best treatment. As a result, the status of compliance with the main treatment axes was obtained for the different cases analyzed.

Keywords: Social rehabilitation, compensatory fuzzy logic, compensatory neutrosophic logic.

1. Introduction

Deprivation of liberty constitutes the mechanism used by States to reduce criminal behavior. During the last years, a new legal concept has appeared, worldwide clear standards regarding the deprivation of liberty were obtained [1]. The fundamental objective of this measure is based on the search for a peaceful coexistence among its peoples.

If an individual violates the peace and harmony of a State, this will imperatively be brought before the jurisdictional entity [2, 3]. The jurisdictional entity will apply a sanction against that individual for undertaking an action classified as a criminal offense.

Someone who have been sanctioned to a custodial sentence have the opportunity to be beneficiaries [4, 5]. The benefits are described through the axes of treatment contemplated in the Integral Organic Penal Code. At present, however, it is not possible to quantify the treatment and its incidence in the change of rehabilitation regimen [6].

Problems like the one previously exposed have been addressed in the scientific literature with Soft Computing techniques. It represents a methodology widely used in situations where the data to be considered is not accurate but indeterminate. These indeterminate data are modeled using the fuzzy set theory. Especially Compensatory fuzzy logic results from an axiom obtained from two different theoretic sources: the decision theory and the logic. Its advantage is that it deals with natural language. However, it preserves the limitations of every fuzzy logic theory, where the indeterminacy is implicitly contained. This is why the compensatory neutrosophic logic extends the compensatory logic in the framework of Neutrosophy. In the 1980s, the international movement called Paradoxism [7] , based on contradictions in science and literature, was founded by Florentin Smarandache, who then extended it to Neutrosophy, a science based on contradictions and their neutrals[8-10] .

From the previous analysis, this research aims to develop a method for treatment and its impact on changing social rehabilitation regimen.

The present paper is divided into the following sections: section 2 contains the preliminary concepts, like compensatory fuzzy logic and compensatory neutrosophic logic. Section 3 is exposes the proposed model. Section 4 contains the application of the model in an actual case study. The paper ends with the conclusions.

2. Preliminaries

This section introduces the fundamental elements that facilitate the understanding of the research. The main theoretical references on the social rehabilitation regime and the treatment of the axes of social rehabilitation are proposed.

2.1 Social rehabilitation regime

The National Social Rehabilitation System is administered by the Ministry of Justice, Human Rights and Worship in Ecuador, represents the State in the regulation of custody, internal security and effective rehabilitation of persons deprived of liberty [11].

The Social Rehabilitation System (SRS) comprises a set of principles, regulations, policies, programs and processes that are fully correlated based on the execution of sentences. The penitentiary system seeks to execute programs that guarantee social rehabilitation before a person deprived of liberty can re-enter their family and social nucleus [12].

The treatment axes establish the set of social indicators that guarantee the social rehabilitation of the individual deprived of liberty. People under custodial sentence have the right to social reintegration and The State guarantees their fulfillment[13].

The treatment for persons deprived of liberty, with a view to their rehabilitation and social reintegration, will be based on the axes: labor, education, culture and sport, health, family and social ties, reintegration. The fundamental objective of the axes of rehabilitation is to guarantee comprehensive activities that generate full restoration in society[14-16].

2.2 Compensatory Fuzzy Logic

The Compensatory Fuzzy Logic (CFL) represents a logical model used for the simultaneous modeling of deductive and decision-making processes [17, 18]. The Compensatory Fuzzy Logic (CFL) represents a logical model used for the simultaneous modeling of deductive and decision-making processes[19], [20].

The CFL uses the Fuzzy Logic scale, which can vary from 0 to 1, to measure the degree of truth or falsehood of its propositions. Propositions can be expressed through predicates. A predicate is a function of the universe X in the interval [0;1].

In order to process the CFL, conjunctive operators are used(^), disjunction(∨), negation(¬) and implication(→), defined in a way that restricts the domain [0;1], [21, 22].

An essential property of this logic is the "principle of gradualness" which affirms that a proposition can be both true and false, as long as it is assigned a degree of truth and falsehood. One way to put the principle of gradualness into practice is to define logics where propositions can be expressed by predicates. Precisely the logic of predicates studies the declarative phrases with a degree of detail, considering the internal structure of the propositions.

The different ways of defining operations and their properties determine different multivalent logics that are part of the Fuzzy Logic paradigm [23]. Multivalent logics are generally defined as those that allow intermediate values between the absolute truth and the total falsehood of an expression. So 0 and 1 are both associated with certainty and accuracy of what is claimed or denied and 0.5 with maximum vagueness and uncertainty [24, 25].

3. Materials and methods

The present method is designed for the treatment and its incidence in the change of social rehabilitation regime. This method should show whether a person in the social rehabilitation process maintains socially responsible behavior or not. The method works through Compensatory Fuzzy Logic [18, 26, 27].

CFL is based on the following axioms:

Compensatory Fuzzy Logic (CFL) [15] is a multivalued logic axiomatic approach different from the one based on t-norms and t-conorms. They satisfy characteristics of descriptive approach of decision-making and the normative approaches of the decision-making.

This is based on four logic operators (*c*,*d*,*n*,*o*). Where *c* is the conjunction operator, *d* is the disjunction operator, *n* is the negation operator and *o* is a fuzzy-strict ordering.

The following axioms are postulated

I. Compensation Axiom $\min(x_1, x_2, \cdots, x_n) \leq c(x_1, x_2, \cdots, x_n) \leq \max(x_1, x_2, \cdots, x_n)$

II. Symmetry or Commutativity Axiom $c(x_1,x_2,...,x_i,...,x_j,...,x_n) = c(x_1,x_2,...,x_j,,...,x_i,...,x_n)$

III. Strict Growth Axiom if $x_1=y_1$, $x_2=y_2$, ..., $x_{i-1}=y_{i-1}$, $x_{i+1}=y_{i+1}$,...., $x_n=y_n$ are different to zero and $x_i>y_i$ then $c(x_1,x_2,...,x_n)>c(y_1,y_2,...,y_n)$

IV. Veto Axiom If $x_i=0$ for any i then $c(x)=0$.

V. Fuzzy Reciprocity Axiom $o(x,y) = n[o(y,x)]$.

VI. Fuzzy Transitivity Axiom If $o(x,y) \geq 0.5$ and $o(y,z) \geq 0.5$, then $o(x, z) \geq \max(o(x,y),o(y,z))$

VII. De Morgan's Laws:

$$n(c(x_1,x_2,...,x_n) = d(n(x_1),n(x_2),...,n(x_n)) \quad n(d(x_1,x_2,...,x_n) = c(n(x_1),n(x_2),...,n(x_n))$$

Implications can be defined in different ways:

S-implication: $S(x,y)=d(n(x),y)$, where d and n are the disjunction and negation operators, respectively.

A particular system is the Geometric Mean Based Compensatory Logic (GMBCL), where conjunction and disjunction operators are expressed by (1) and (2), respectively, when the domain is discrete, [28-30].

$$c(x_1, x_2,..., x_n) = \sqrt[n]{\prod_{i=1}^{n} x_i} = \exp\left(\frac{1}{n}\sum_{i=1}^{n}\ln(x_i)\right) \qquad (1)$$

Disjunction is the dual of the conjunction:

$$d(x_1, x_2,..., x_n) = 1-\sqrt[n]{\prod_{i=1}^{n}(1-x_i)} = 1-\exp\left(\frac{1}{n}\sum_{i=1}^{n}\ln(1-x_i)\right) \quad (2)$$

Paradoxism is an international movement in science and culture, founded by Romanian Scholar Florentin Smarandache in 1980s, based on excessive use of antitheses, oxymoron, contradictions, and paradoxes[31]. During three decades (1980-2020) hundreds of authors from tens of countries around the globe contributed papers to 15 international Paradoxist anthologies[32]. In 1995, the author extended the Paradoxism to a new branch of philosophy called Neutrosophy [33] (based on opposites and their neutral), that gave birth to many scientific branches, such as: neutrosophic logic [34], neutrosophic probability and statistics[35], neutrosophic multi-criteria methods [36]. All of them with multiple applications in engineering, computer science, soft sciences etc.[37-39].

Definition 1: A *neutrosophic number* N is defined as follows:

$$N = d + I \qquad (3)$$

Where d is called *determinate part* and I is called *indeterminate part*.

Given $N_1 = a_1 + b_1 I$ and $N_2 = a_2 + b_2 I$ two neutrosophic numbers, some operations between them are defined as:

$N_1 + N_2 = a_1 + a_1 + (b_1 + b_2)I$ (Addition);

$N_1 - N_2 = a_1 - a_1 + (b_1 - b_2)I$ (Difference),

$N_1 \times N_2 = a_1 a_2 + (a_1 b_2 + b_1 a_2 + b_1 b_2)I$ (Multiplication),

$\frac{N_1}{N_2} = \frac{a_1+b_1 I}{a_2+b_2 I} = \frac{a_1}{a_2} + \frac{a_2 b_1 - a_1 b_2}{a_2(a_2+b_2)} I$ (Division).

Definition 2: A Compensatory Neutrosophic Logic (CNL) extends the axiomatic of CFL to the domain of $[0,1] \cup \{I\}$.

Description of second level compound predicates

SRS(x): The Social Rehabilitation Regime is well valued if it adequately complies with the current legal framework and the indicators of the axes of social rehabilitation. If the report of compliance with the legal framework is somewhat unsatisfactory, it must be compensated with very good compliance with the indexes of the rehabilitation axes.

Expression of compound (third level) predicates associated with second level compound predicates

IL(x): Labor and educational integration.

IC(x): Cultural and sports integration.

VF(x): Family integration.

Expression of second-level predicates in CFL predicates.

From natural or professional language to the CFL predicate, as seen in equation 3:

$$SRS_{(x)} = IL_{(x)} \wedge IE_{(x)}{}^2 \wedge VF_{(x)} \wedge \left(\neg VF_{(x)} \rightarrow \left(IL_{(x)}\right)^2 \wedge \left(IE_{(x)}\right)^3\right) \qquad (4)$$

For this work, a relationship is considered $SRS_{(x)} \rightarrow$ "Satisfaction" if the truth of the predicate is ≥ 0.9[40], [41], [20]. From this, the following steps are established:

1. Initial step: Reading the data to perform the discovery.
2. Execution of discovery task.

3. Evaluation of the results considering the sample.
4. Hypothesis approach: Definition of new discovery and evaluation projects under consideration.

Description of third level compound predicates.
IL(x): The prison system has an adequate labor and educational integration.
VF(x): The prison system has an adequate family integration.

Expression of compound (fourth level) and simple predicates associated with third level compound predicates
Associated Predicates *IL(X)*
PT(x): The system enhances access to decent work.
PE(x): The system promotes inclusion in education.

Associated Simple Predicates *VF(X):*
IF(x): The system promotes an adequate family integration.
IS(x): The system promotes adequate social integration.
RS(x): The system promotes an adequate social reintegration.

Expression of third-level predicates in predicates of FCL

$$\mathrm{CIL}_{(x)} = \mathrm{PT}_{(x)} \wedge \mathrm{PE}_{(x)} \tag{5}$$

$$\mathrm{CVF}_{(x)} = \mathrm{IF}_{(x)} \wedge \mathrm{IS}_{(x)} \wedge \mathrm{RS}_{(x)} \tag{6}$$

Simple Predicates Evaluation Form.

The simple predicates from which the compound predicates will be evaluated will be measured according to the fulfillment of the analyzed values that arise from the study of the behavior of the indicators of social rehabilitation.

The difference of our approach with the FCL is that we incorporate the indeterminacy, which permits more accuracy using CNL.

4. Results and discussions

The Fuzzy Tree associated with the FCL-based Social Rehabilitation Regime and reflects the relationships between the simple predicates to evaluate, the compound predicates and the final predicate. Figure 1 shows the resulting associated tree.

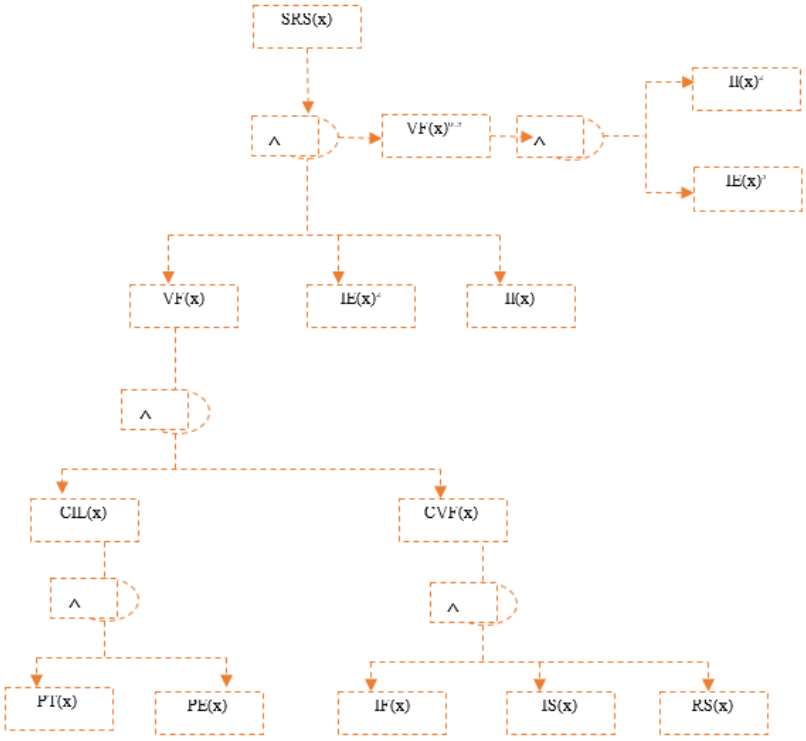

Figure 1. Fuzzy Tree associated with the FCL-based Social Rehabilitation Regime.

To obtain the data to be analyzed, the criteria of 7 penitentiary institutions was used.

Institutions	PT(x)	PE(x)	IF(x)	IS(x)	RS(x)
I_1	[3.00, 3.5]	[2.88, 3.90]	[2.76, 2.78]	[2.92, 2.95]	[0.88, 0.89]
I_2	[2.74, 2.76]	[2.95, 3.00]	[2.67, 3.00]	[2.63, 2.64]	[0.64, 0.65]
I_3	[2.45, 2.46]	[2.13, 2.2]	[2.67, 2.68]	[2.89, 2.90]	[1.52, 1.53]
I_4	[2.96, 3.00]	[1.79, 1.80]	[1.64, 1.67]	[1.85, 1.86]	[1.52, 2.00]
I_5	[2.60, 2.65]	[2.35, 2.37]	[2.47, 2.50]	[2.29, 2.30]	[1.86,1.90]
I_6	[2.75, 2.79]	[2.92, 2.95]	[3.00, 3.01]	[3.00, 3.01]	[2.12,2.14]
I_7	[2.70, 2,75]	[2.90, 2.92]	[2.80, 2.81]	[2.60, 2.62]	[2.00,2.02]

Table 1. Results of the predicates in the 7 institutions analyzed.

Legend:
I: People from penitentiary institutions.

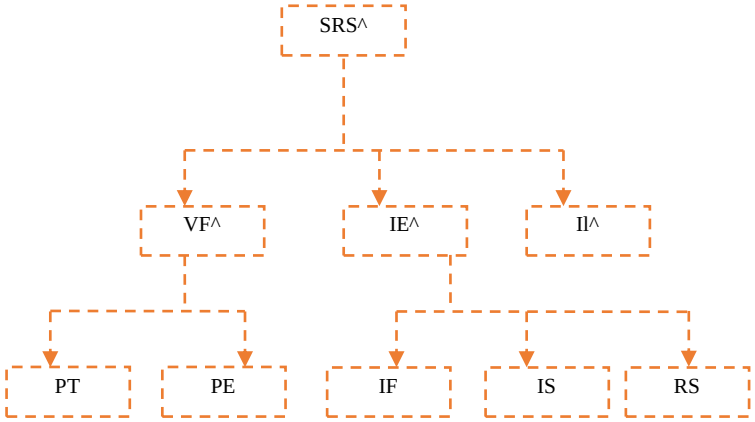

Figure 2. Fuzzy tree of Social Rehabilitation based on FCL.

Other results obtained from the modeling can be seen in Table 2 where the blocks of institutions are located according to their impact on social rehabilitation based on the truth scale determined in the FCL.

State	Scale	Incidence of the social rehabilitation regime	Institution per state of the social rehabilitation
1	0 - 0.2	Inadequate	14 % (1 institution)
2	0.2 - 0.4	Very low	14% (1 institution)
3	0.4 - 0.6	Appropriate	42.8 % (3 institutions)
4	0.6 - 0.8	Good	28.5 % (2 institutions)
5	0.8 - 1	Excellent	

Table 2. Social Rehabilitation Values obtained through data processing.

The analysis of the Social Rehabilitation Regime was developed through the modeling of the Compensatory Neutrosophic Logic that allowed us to evaluate the behavior of compliance with the fundamental axes. 5 penitentiary institutions were used as the object of study.

The use of the Compensatory Neutrosophic Logic for the analysis of Social Rehabilitation showed that:

- A value of 42.8%, representing 3 institutions, comply with Social Rehabilitation in an appropriate way.
- A value of 28.5%, representing 2 institutions, comply with the Social Rehabilitation in a good way.
- However, 14.4%, representing 1 institution, complies with Social Rehabilitation in a very low value.
- A value of 14.4%, representing 1 institution, comply with Social Rehabilitation in an inadequate way.

In the 5 institutions taken as an example for the proposed model, it can be noted that: although the results relation shows how a compound predicate seems to have a good behavior in its internal relations, some variations may occur. Variations are largely conditioned depending on the characteristics of the institution being modeled.

Conclusions

This work is based on the use of information obtained from the social rehabilitation process, for the evaluation of the status of the process. It is an interesting way to link the workers of the penitentiary institutions in the evaluation of the social rehabilitation regime.

The application of a mathematical model based on the Compensatory Neutrosophic Logic constitutes an effective instrument for evaluating the treatment of the Social Rehabilitation System.

For future research, it should result in the formation of knowledge bases on the behavior of treatment in social rehabilitation. This will promote the deepening of knowledge about the subject in question; reference patterns that serve to conduct behavioral analysis.

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