



Applying Neutrosophic Natural Language Processing to Analyze Complex Phenomena in Interdisciplinary Contexts

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Abstract. The paper addresses the challenge of integrating natural language processing (NLP) with neutrosophic logic to solve problems where uncertainty, ambiguity, and indeterminacy play a critical role. This approach becomes particularly relevant in an increasingly digitalized world, where human-machine interaction requires a deeper understanding of linguistic and contextual nuances. Despite advances in conventional NLP, many existing methodologies lack tools to effectively manage undefined or contradictory elements present in real data. In this context, neutrosophic logic offers an innovative framework to model and analyze complex and multifaceted human perceptions. The study applies a methodology that combines advanced NLP techniques with neutrosophic analytical tools, allowing to processing of texts with simultaneous degrees of truth, falsity, and indeterminacy. The results reveal a significant capacity to identify linguistic patterns in high-uncertainty scenarios, with practical applications in areas such as artificial intelligence, decision-making, and semantic analysis. This approach not only extends the boundaries of traditional NLP, but also provides an adaptable framework for studying complex phenomena in interdisciplinary contexts. Ultimately, this work contributes to the development of more intelligent systems, capable of accurately handling the ambiguity inherent in human language.

Keywords: natural language processing, neutrosophic logic, uncertainty, ambiguity, indeterminacy, human-computer interaction, semantic analysis, linguistic patterns, artificial intelligence, decision making.

1. Introduction

The semi-open regime is the process of social rehabilitation of the convicted person who meets the requirements and norms of the progressive system to carry out his activities outside the center of execution of the sentence, under the supervision of the Technical Body. In this way, it allows him to carry out family, labor, social, and community reintegration activities.

Penitentiary law seeks to establish a balance between punishment and the resocialization of convicted prisoners, to promote their reintegration into society. In this context, the semi-open regime has emerged as an alternative that allows prisoners to serve their sentence in a less restrictive environment and with greater opportunities for social reintegration. However, in the case of those convicted of homicide, there is a worrying violation of their right to a semi-open regime. These individuals are frequently excluded from this type of prison, which raises questions about the justification and proportionality of this practice.

The exclusion of those convicted of homicide from the semi-open regime raises ethical and legal questions. On the one hand, it is argued that the seriousness of the crime and the perceived dangerousness of the prisoners justify the denial of this penitentiary benefit. However, this approach poses a challenge to the fundamental principles of criminal law and human rights [1], among which are social reintegration and proportionality of sentences [2].

Mandatory requirements for the semi-open regime:

1. Having served sixty percent (60%) of the sentence imposed by a final conviction; except in cases where the person deprived of liberty is the only appellant in an extraordinary appeal for cassation.
2. Evaluation and qualification report that has a minimum average of five (5) points during the execution of the individualized sentence fulfillment plan.
3. Certificate of not having been sanctioned for committing serious or very serious disciplinary offences during the sentence, issued by the highest authority of the centre.
4. Certificate of being classified at a minimum-security level, issued by the highest authority of the detention center.
5. Document proving the fixed address where the person deprived of liberty will reside, which may consist of a lease agreement, a commitment contract signed by the person deprived of liberty or a third party, or any other supporting document.
6. A legal report from the center indicates that the person deprived of liberty does not have another pending criminal process with preventive detention or a final conviction. If the person deprived of liberty has a process with conditional suspension of the sentence or that will require conditional suspension of the procedure other than that requesting the change of regime, the respective resolution declares the sentence extinguished by compliance with the conditions and terms established by the competent authority.
7. Psychological report from the center, which concludes the conditions for the reintegration of the person deprived of liberty. In addition, if there are certificates of participation in group support, individual psychotherapy, or therapeutic communities during the time of deprivation of liberty, these will be attached to the report.

Persons deprived of liberty who have been convicted of homicide [3], femicide [4] [5], contract killing, crimes against personal integrity and freedom resulting in death, robbery with fatal consequences, crimes against sexual and reproductive integrity, human trafficking and migrant smuggling, crimes of violence against women or members of the family unit cannot access this regime. Bribery, extortion, embezzlement, illicit enrichment, obstruction of justice, overpricing in public contracts, acts of corruption in the private sector [6], money laundering, unjustified private enrichment, crimes of illicit trafficking of controlled substances on a high and large scale, terrorism, organized crime, cattle rustling resulting in death, and serious violations of human rights and crimes against international humanitarian law.

A. Ecuadorian Penitentiary System. Regulations and Characteristics.

In Ecuador, the penitentiary system is structured around a legal framework consisting of the Comprehensive Organic Penal Code (COIP) and various laws and regulations, such as the Organic Law of the Penitentiary Public Service and the Law on the Execution of Sentences, which together regulate from general principles to specific aspects of penitentiary management. This set of regulations promotes respect for human rights [7] [8] [9], individualized treatment of inmates, classification by categories according to risk factors, and the implementation of rehabilitation and social reintegration programs. Thus, it includes paid prison work and active participation in civil society. Despite these provisions, the system faces significant challenges such as overcrowding and

poor living conditions, in response to which the government has initiated improvement efforts, including the construction of new facilities and decongestion policies [10].

B. Violation of constitutional rights of prisoners in semi-open or closed regimes

In Ecuador, the penitentiary system has the responsibility of guaranteeing the respect and protection of the constitutional rights of inmates [11], even in semi-open and closed penitentiary regimes. However, in practice, situations of violation of these rights may arise. Some of the possible violations of constitutional rights in these penitentiary regimes are:

1. **Overcrowding:** Overcrowding is a recurring problem in Ecuadorian prisons and can affect respect for the constitutional rights of prisoners. The lack of adequate spaces and decent living conditions can lead to problems with health, safety, and access to basic services.
2. **Violence and security:** Semi-open and closed prison regimes may face challenges in terms of violence and security within prisons. The lack of effective control and adequate security measures may expose prisoners to risky situations and violate their right to personal integrity.
3. **Access to basic services:** Prisoners in semi-open and closed regimes must have access to basic services, such as medical care, adequate nutrition, drinking water, hygiene, and sanitary conditions. Inadequate provision of these services may constitute a violation of prisoners' constitutional rights.
4. **Restriction of freedoms:** In semi-open and closed regimes, inmates have certain restrictions on their freedom of movement and personal autonomy. However, these restrictions must be justified and proportionate, always respecting the fundamental rights of inmates.
5. **Right to rehabilitation and social reintegration:** Prisoners have the right to participate in rehabilitation and social reintegration programs during their period of incarceration. If these programs are not implemented effectively, they may limit the ability of prisoners to properly reintegrate into society once they have served their sentence.

The purpose of this article is to analyze in depth the issue of the violation of the right to a semi-open prison regime for persons convicted of homicide. It also examines the possible justifications put forward for denying them this type of prison regime, as well as the implications and consequences of this exclusion for both individuals and society.

Proposals and recommendations are presented to seek alternatives that ensure the right to a semi-open regime for persons convicted of homicide, following the principles of criminal law and human rights. The ultimate goal is to promote a more just and effective penitentiary system that encourages the resocialization of prisoners without neglecting the seriousness of the crimes committed.

This study focuses on the violation of the right to semi-open regime in persons convicted of homicide, by analyzing legislation, judicial practices, and individual cases through a descriptive and analytical approach. Through the review of files and interviews with experts and convicted persons, a wide range of data was collected, allowing for a sentiment analysis. This allowed the identification of patterns and themes relevant to understanding the attitudes and emotions associated with the semi-open regime.

Despite some limitations related to the sample and data accessibility, the results obtained provide valuable insight into the challenges faced by people convicted under this regime, thus offering significant contributions to the debate on penal reforms focused on rehabilitation and social reintegration.

2. Related work.

2.1 Neutrosophic analysis.

Neutrosophics is a new branch of philosophy that studies the origin, nature and scope of neutralities, created by Professor Florentin Smarandache. Neutrosophic logic and sets, on the other hand, constitute a generalization of fuzzy logic and Zadeh's sets, and especially of Atanassov's intuitionistic logic, with multiple applications in the field of decision-making [12,13].

A neutrosophic set is defined by the following elements: μ true, γ indeterminate and τ false of x in S , respectively, and their images constitute standard or nonstandard subsets within the range $(0;1)$. For N in the universe of discourse, the single-valued neutrosophic set S over N is defined as an object in the representation $S = \{\langle n, \mu_S(n), \gamma_S(n), \tau_S(n) \rangle : n \in N\}$.

Where $\mu_S(n), \gamma_S(n), \tau_S(n)$ the following condition 0 holds $0 \leq \mu_S(n), \gamma_S(n), \tau_S(n) \leq 3$ for all $n \in N$. Therefore, to define each neutrosophic number to be expressed in the form v, i, f for neutrosophic sentiment analysis modeling. Therefore, the following functions are defined [14,15] :

$v = \mu_S(n)$ for true membership functions, where $\in \{0,1\}$.

$i = \gamma_S(n)$ for indeterminate membership functions, where $\in \{0,1\}$.

$j = \delta_A(n)$ for false membership functions, where $\in \{0,1\}$.

Therefore, the neutrosophic number defined for the study is determined as $S = (v, i, f)$, $v, i, f \in \{0,1\}$ and satisfies the following condition $0 \leq v + i + f \leq 3$. Therefore, it is defined as the scoring function Y of a neutrosophic number as defined by the methodology analyzed [13,16,17].

Sentiment analysis, VADER.

VADER (Valence Aware Dictionary and Sentiment Reasoned) is a sentiment analysis tool specifically designed for social media texts, but can also be applied to a wide range of contexts. It is particularly popular due to its focus on Internet-specific language, including handling emoticons, acronyms, and specific web jargon.

The integration of Neutrosophic with the VADER method for sentiment analysis in NLP opens new avenues for exploring public opinion on sensitive and multifaceted issues [14] [15] This approach is a powerful tool for researchers and analysts interested in unraveling the complex dynamics of perception and opinion. It therefore offers valuable insights for policy formulation, communication strategies, and the promotion of a more inclusive social dialogue.

The study of public perception regarding the violation of the right to a semi-open regime of persons convicted of homicide crimes is significantly enriched by the use of advanced natural language processing (NLP) techniques [16] [17], in particular by incorporating Neutrosophy into sentiment analysis [19,20,21]. This approach allows for a more nuanced and in-depth understanding of opinions and emotions expressed in various texts, such as articles, social media comments, and public speeches. Neutrosophy offers a new dimension in sentiment analysis by considering states of indeterminacy alongside positive and negative sentiments. An explanation of how to integrate this approach with the VADER method for sentiment analysis is presented below [22, 23, 24].

Step 1: Data collection.

The first step is to collect a diverse set of texts addressing the topic of interest, from online forum posts to social media comments and op-eds, court transcripts, news articles, and discussion forums. These texts provide a rich database for analysis.

Step 2: Data preprocessing.

Before analyzing the data, it is essential to perform preprocessing to clean and normalize the text. This includes removing irrelevant elements (such as links and special characters), term normalization, and tokenization to break down the text into manageable units.

Step 3: Integrating Neutrosophic with VADER

Traditionally, VADER assigns scores to texts reflecting positive, negative, and neutral sentiments. The integration of Neutrosophic involves extending this analysis to also consider the degrees of indeterminacy present in sentimental expressions. This is achieved by adapting the algorithm to assess the uncertainties and indeterminacies of the language used, which is especially relevant in speeches addressing complex or sensitive topics.

Step 4: Analysis and interpretation

Analysis using this enriched method allows not only to identify general sentiment trends (positive, negative, or neutral/indeterminate), but also to capture the presence of ambivalent or uncertain opinions, reflecting a more complete picture of public discourse. This detailed analysis helps to identify areas of consensus and controversy, as well as to better understand the complexity of social perceptions.

3. Results and discussion

To represent the results, a table is used that reflects the neutrosophic scores of each text analyzed, categorizing the opinions as positive, negative, neutral, and indeterminate. Using the VADER method adapted to include Neutrosophy, the texts are evaluated to determine the emotional tone and the prevalence of positive, negative, neutral or indeterminate opinions. Each text receives scores in these dimensions (see Table 1).

Table 1: Linguistic terms to represent emotional tone.

Linguistic Scale (LS)	SVNN (v, i, f)	Category
Extremely Positive (EP)	(0.95, 0.15, 0.10)	It reflects expressions of support or approval towards the semi-open regime.
Positive (P)	(0.75,0.30,0.25)	
Indeterminate (I)	(0.50,0.45,0.50)	Texts that present facts or arguments without expressing a clear emotional inclination.
Negative (N)	(0.25,0.85,0.75)	Indicates criticism or rejection of exclusion from this regime.
Extremely negative (ES)	(0.15,0.90,0.95)	

To develop a natural language processing (NLP) and sentiment analysis tool using VADER, adapted to the semi-open regime topic and enriched with a neutrosophic perspective, a set of keywords or phrases is first defined (see Table 2).

Table 2: Classification of keywords or phrases obtained from the data source.

No .	Keywords or phrases	Classification close to LS	Relationship
1	Social reintegration	P	Related to the objective of the semi-open regime.
2	Overpopulation	N	It reflects problems within the prison system.
3	Opportunity for rehabilitation	P	Focus on rehabilitation.
4	Violation of rights	IS	Legal or ethical issues.
5	Second chance	EP	Concept of redemption.
5	Insecurity	ES	Concerns inside the prison.
7	Penitentiary reform	I	Depending on the context, it can be seen as a solution or a challenge.
8	Stigmatization	north	Problems of social reintegration.
9	Restorative Justice	N	Focus on repairing the damage.
10	Recidivism	IS	Recidivism of crimes.
11	"perhaps"/"possibly"	I	-

Interpretation and discussion:

- Activity: Analyze the results to understand how the captured narratives and sentiments influence legal decisions and public opinion.
- Expected outcome: Knowledge of the public and legal perception of exclusion from the semi-open regime, together with the identification of areas for action and reform.

Proposals and suggestions:

- Activity: Formulate recommendations based on the findings to promote more just and effective prison policies.
- Expected outcome: Proposals to improve access to the semi-open regime and support social reintegration.

The results indicate a clear predominance of negative opinions and a high degree of indeterminacy in the narratives analyzed. The main concerns revolve around social reintegration and criminal justice, with recurrent criticism of the rigidity of policies that exclude those convicted of homicide from the semi-open regime. Linguistic patterns suggest a strong correlation between the language used in legal discourses and public perception, especially in terms of the dehumanization and stigmatization of convicts. [23]

Neutrosophic sentiment analysis highlights the complexity of views on exclusion from the semi-open regime for people convicted of murder. The indeterminacy captured in this study reflects uncertainty in society and the legal system about how best to approach the reintegration of people

who have committed serious crimes. It is argued that indeterminacy and negativity in narratives could hamper penal reform efforts, emphasizing the need for a more balanced and evidence-based approach. Some strategies are therefore proposed:

Together, these strategies aim to create a more humane and effective criminal justice system that recognizes the dignity and potential for the reintegration of each individual, thus contributing to a safer and more just society. Among the alternatives to be developed are:

- Implementation of tailored reintegration programs: Develop and implement social and work reintegration programs tailored to the individual needs of inmates. This includes vocational training, continuing education, and psychological and mental health support. It requires a detailed analysis of each inmate's profile to determine the most appropriate interventions, facilitating effective reintegration into society and reducing recidivism rates.
- Legislative reform to promote semi-open prisons: Amend criminal legislation to make access criteria to semi-open prisons more flexible, taking into account not only the nature of the crime committed but also the conduct of the inmate, his commitment to rehabilitation, and the risk of reoffending. This includes removing unnecessary legal barriers and promoting a culture of restorative justice focused on repairing harm and reconciliation.
- Strengthening prison infrastructure and resources: Increase investment in prison infrastructure and human resources to ensure that prisons have the capacity and programs necessary to facilitate the rehabilitation and social reintegration of inmates. This includes expanding facilities suitable for semi-open regimes, increasing the number of personnel trained in rehabilitation, and implementing technologies that allow for the ongoing monitoring and support of inmates in the reintegration process.

The results obtained through sentiment analysis, using the combination of Neutrosophic and the VADER method, reveal deficiencies in the Ecuadorian penitentiary system, especially in the perception and access to the semi-open regime by inmates convicted of homicide. This analysis highlights not only the lack of knowledge of inmates about their rights and the semi-open regime but also the influence of the rigidity of the system and social stigmatization on their negative perceptions. The combination of legal restrictions, strict criteria, and the scarcity of rehabilitation programs, together with stigmatization, highlights how these perceptions and realities hinder effective penal reforms. It therefore underlines the need to promote strategies to achieve a more balanced, inclusive and evidence-based approach to improving the criminal justice system.

4. Conclusion

This study highlights the important issue of the violation of the right to a semi-open penal regime for persons convicted of certain crimes, pointing out that the unjust limitation of access to this penal regime seriously compromises the possibility of effective social reintegration. It is evident that such a violation negatively affects both the fundamental rights of convicted persons and social well-being in general. In addition, it prevents the implementation of appropriate rehabilitation programs, increasing the risk of recidivism and hindering the social reintegration of individuals.

Sentiment analysis integrating Neutrosophy with the VADER method highlights the negative and indeterminate perception around criminal justice and reintegration, underlining the urgency of informed and balanced penal reforms. At the same time, it emphasizes the critical importance of adhering to the principle of individualization of punishment, which requires a detailed examination of the circumstances of each case to personalize sanctions according to the needs and characteristics

of convicts. The rigidity in the application of sentences, especially the exclusion of the semi-open regime, contradicts the principles of proportionality and humanity. Thus, it reveals a significant gap between current penitentiary policies and the effective need for rehabilitation and social reintegration of convicts.

The urgent need to develop policies and mechanisms to ensure the right of convicted prisoners to a semi-open regime is stressed. To this end, effective rehabilitation programs must be implemented, monitoring measures strengthened, and social reintegration promoted as a central objective of the penitentiary system. Guaranteeing human rights and promoting a penal system that prioritizes effective reintegration is essential to progress toward a more equitable and humane administration of justice, capable of reducing recidivism and improving security and social cohesion.

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