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Measuring Legal Efficacy in Urban Animal Protection: A Novel Approach with NeutroAlgebra and Linguistic Models

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Abstract. This study, conducted in the Ecuadorian context, introduces an innovative method employing NeutroAlgebra and a 2-tuple neutrosophic linguistic model to evaluate the efficacy of legal and doctrinal foundations for the protection of urban fauna, focusing on dogs and cats. Faced with challenges such as abandonment and deficient enforcement of regulations in urbanized societies, the research addresses the complexity of measuring the true effectiveness of legal frameworks, considering the inherent uncertainties in their application and interpretation. The analysis is based on expert assessments across five fundamental categories. Preliminary findings, derived from aggregated expert opinions, indicate varied levels of perceived effectiveness: citizen participation (F5) emerges as a robust factor with a 'High' rating. In contrast, the constitutional basis (F1), regulatory framework (F2), and judicial interpretation (F4) are perceived as 'Somewhat High' efficacy. Critically, institutional implementation (F3) is identified as the weakest area, with a 'Rather Low' rating. These results suggest that while citizen commitment and a legal basis exist, significant challenges persist in the practical execution and effective enforcement of animal protection laws.

Keywords: Urban Wildlife Protection, Animal Law, NeutroAlgebra, 2-tuple Neutrosophic Linguistic Model, Legal Efficacy, Canine and Feline Welfare

1. Introduction

Animal welfare of domesticated, urban wildlife (canines and felines) has emerged as a global socioeconomic and legal issue, indicating that with an increasingly urbanized world comes a more socially aware and legally responsive inclination to protect animals. This article focuses on the legal and doctrinal justifications for animal welfare law as the critical component of analysis within a world where human-animal interaction is complicated by urbanization [1]. The problem is relevant to the sustainability of urban populations and quality of life for those associations with pets are effective, social and cultural additions to the household [2]. Recent developments indicate that animal welfare legislation [3] decreases incidence of urban crime while increasing human social bonding and stability for the animals in question. Therefore, a proper evaluation of legislative law brings an answer to feasible welfare.

Throughout history, societies have evolved in their perception of animals, moving from considering them mere resources to recognizing them as sentient beings with inherent rights. In the 20th century, countries such as the United Kingdom and Germany began to enact specific animal protection laws,

setting precedents for modern legislation [4]. However, in urban contexts, the implementation of these regulations faces obstacles such as a lack of institutional resources and judicial inconsistency [5]. In Latin America, for example, the proliferation of abandoned dogs and cats in cities has prompted legal reforms, although gaps in their practical application persist [6]. This historical overview underscores the need for innovative approaches that address the complexities of animal protection in densely populated environments.

Thus, in modern-day urbanized societies, packs of dogs and cats are taken into concentrated areas as populations continue to grow, creating pockets of vulnerable populations or abandoned dogs and cats which only exacerbate the problems of abuse and overpopulation [7]. Where certain all statutes exist that cover a great deal for at-risk animals, proper intentions exist but fail due to lack of enforcement or failure to necessitate enforcement measures [8]. Moreover, such problems are compounded by judicial interpretive trends which render some applications vague [9]. Thus, this project's purpose is to analyze the ability of current legal frameworks to distinguish between the protection of natural wildlife and animal rights. Therefore, the research problem posed is: How can the effectiveness of legal frameworks and doctrinal support for the protection of urban dogs and cats be assessed, considering the inherent ambiguities and non-specificity in their application? From a perspective that without fostering a solution to a specific problem, the nature of the law does not exist with certainty [10]. The research problem is important because animal abandonment and neglect happen in urban cities across the world at nearly detrimental levels; however, assessments must extend beyond single-focus logic because these systems established are much more complicated than they seem [11].

The gap in knowledge stems from the creation of a new application via the original research question and a new approach via a NeutroAlgebra and neutrosophic tuple linguistic model [12]. This model will evaluate five predictors of effectiveness that may lend greater nuance beyond simple aggregate effectiveness: constitutional foundation, special legislation, institutional implementation, judicial interpretation, and citizenship involvement. The application of such determinants will note strengths and weaknesses of the legal situation in comparison to findings regarding dog/cat protective legislation in urban settings and provide a foothold for situationally appropriate, practical suggestions.

This research project is of crucial importance at this time to animal advocates, the legal community and policymakers who may benefit from a more effectively informed design for current legislative, active pursuits for animal welfare and sustainable usage in the city. In addition, there exists a gap in comparison to findings relative to judicial assessment and implementation, thus rendering this a transferrable evaluative tool for any legal forum. Such investigation is globally necessary, as it takes an interdisciplinary approach to fulfill the need for scientific, legal and ethical protective abilities for animals through suggested improvements. This research has a purpose in line with the research question. First, this study endeavors to determine how effective dog and cat protections are in an urban environment by assessing them through a neutrosophic model. Second, this study endeavors to determine what institutional actions and judicial roadblocks prevent any legislation from being truly implemented. Third, this study endeavors to provide practical suggestions for improving animal protection efforts based on the findings of the second endeavor.

2. Preliminaries.

2.1. The 2-tuple neutrosophic linguistic model

Definition 1. ([13,14]) Let be $S = \{s_0, s_1, \dots, s_g\}$a set of linguistic terms and $\beta\epsilon[0, g]$a value representing the result of a symbolic operation, then the linguistic 2-tuple expressing the information equivalent to β is obtained using the following function:

$$\Delta: [0, g] \to S \times [-0.5, 0.5)$$

$$\Delta(\beta) = (s_i, \alpha) \quad (1)$$

Where s_i is such that $i = \text{round}(\beta)$ and $\alpha = \beta - i, \alpha \in [-0.5, 0.5)$ "round" is the usual rounding operator, $s_i$is the index label closest to β and α is the value of the symbolic translation.

It should be noted thatΔ^{-1}: $\langle S\rangle \to [0, g]$ is defined as $\Delta^{-1}(s_i, \alpha) = i + \alpha$. Thus, a linguistic 2-tuple $\langle S\rangle$is identified by its numerical value in $[0, g]$.

Definition 2.([15, 16]) Let $S = \{s_0, \ldots, s_g\}$ be a *2-tuple linguistic set* (2TLS) with odd cardinality g+1. We define for $(s_T, a), (s_I, b), (s_F, c) \in$ Lya, b, c $\in [0, g]$, where $(s_T, a), (s_I, b), (s_F, c) \in$ Lthey independently express the degree of truth, indeterminacy, and falsity by 2TLS. *The 2-tuple linguistic neutrosophic number* (2TLNN) is defined as follows:

$$l_j = \left\{(s_{T_j}, a), (s_{I_j}, b), (s_{F_j}, c)\right\} \quad (2)$$

Where $0 \le \Delta^{-1}(s_{T_j}, a) \le g$, $0 \le \Delta^{-1}(s_{I_j}, b) \le g$, $0 \le \Delta^{-1}(s_{F_j}, c) \le$ gand $0 \le \Delta^{-1}\left(s_{T_j}, a\right) + \Delta^{-1}\left(s_{I_j}, b\right) + \Delta^{-1}(s_{F_j}, c) \le 3g$.

Definition 3. ([15, 16]) The score and accuracy functions allow us to classify 2TLNN.

Let be $l_1 = \left\{(s_{T_1}, a), (s_{I_1}, b), (s_{F_1}, c)\right\}$a 2TLNN in L, the score and accuracy functions $l_1$are defined as follows, respectively:

$$S(l_1) = \Delta\left\{\frac{2g + \Delta^{-1}(s_{T_1}, a) - \Delta^{-1}(s_{I_1}, b) - \Delta^{-1}(s_{F_1}, c)}{3}\right\}, \Delta^{-1}(S(l_1)) \in [0, g] \quad (3)$$

$$H(l_1) = \Delta\left\{\frac{g + \Delta^{-1}(s_{T_1}, a) - \Delta^{-1}(s_{F_1}, c)}{2}\right\}, \Delta^{-1}(H(l_1)) \in [0, g] \quad (4)$$

2.2. NeutroAlgebra and PROSPECTOR function

Definition 4 [17]: Let X be a given non-empty space (or simply a set) included in a universe of discourse U. Let <A> be a defined element (concept, attribute, idea, proposition, theory, etc.) in the set X. Then, by the process of neutersification, we divide the disjoint set, depending on the application, but they are exhaustive (their union is equivalent to the whole space).

A *NeutroAlgebra* is an algebra with at least one *NeutroOperation* or one *NeutroAxiom* (an axiom that is true for some elements, uncertain for other elements, and false for other elements).

NeutroAlgebra is a generalization of *Partial Algebra,* an algebra with at least one *Partial Operation,* while all its Axioms are true (classical axioms).

Definition 5 [17]: A function f: X → Yis called *a Partial Function* if it is well-defined for some elements in X and is undefined for all other elements in X. Therefore, there exist some elements $a \in X$ such that $f(a) \in Y$(well-defined), and for all other elements $b \in X$that we have, $f(b)$it is undefined.

Definition 6 ([17]): A function f: X → Y is called *a NeutroFunction* if it has elements in X for which the function is well-defined {degree of truth (T)}, elements in X for which the function is indeterminate {degree of indeterminacy (I)}, $T, I, F \in [0, 1]$and $(T, I, F) \neq (0, 0, 1)$elements $(T, I, F) \neq (1, 0, 0)$in

Classification of functions

i. Function (Classical), which is a well-defined function for all elements in its domain of definition.
ii. NeutroFunction, which is a function that is partially well-defined, partially indeterminate, and partially externally defined in its domain of definition.

iii. AntiFunction, which is an externally defined function for all elements in its domain of definition.

Definition 8 ([18]): A *(classical) algebraic structure (or algebra) is a* non-empty set A equipped with some (completely well-defined) operations (functions) on A and satisfying some (classical) axioms (completely true) - according to Universal Algebra.

Definition 9 ([18]) : A *(classical) partial algebra* is an algebra defined on a non-empty set *PA* which is equipped with some partial operations (or partial functions: partially well-defined and partially undefined). Whereas the axioms (laws) defined on a Partial Algebra are all totally (100%) true.

Definition 10 ([18]): A *NeutroAxiom* (or *Neutrosophic Axiom*) defined on a non-empty set is an axiom that is true for some set of elements {degree of truth (T)}, indeterminate for another set of elements {degree of indeterminacy (I)}, or false for the other set of elements {degree of falsity (F)}, where $T, I, F \in [0,1]$, with $(T, I, F) \neq (1,0,0)$which represents the (classical) Axiom, and $(T, I, F) \neq (0,0,1)$which represents the AntiAxiom.

Classification of algebras [19, 20, 21]

i. A *(classical) algebra* is a *non-empty CA set* that is endowed with total operations (or total functions, i.e., true for all elements of the set) and (classical) axioms (also true for all elements of the set).
ii. A *NeutroAlgebra* (or *NeutroAlgebraic Structure)* is a *non-empty set of NA* that is provided with: at least one *NeutroOperation* (or *NeutroFunction*), or a *NeutroAxiom* that refers to the set of operations (partial, neutral or total).
iii. An *AntiAlgebra* (or *AntiAlgebraic Structure)* is a *non-empty set of AA* that is equipped with at least one *AntiOperation* (or *AntiFunction*) or at least one *AntiAxiom* .

Furthermore, the PROSPECTOR function is defined as follows; it is a mapping from $[-1,1]^2$within $[-1,1]$with the formula, [22] :

$$P(x,y) = \frac{x+y}{1+xy} \quad (5)$$

This function is a uninorm with neutral element 0, so it satisfies commutativity, associativity and monotonicity, see the different types of uninorms in [17-20] , which include those defined for offsets [26-28] . $P(-1,1)$and $P(1,-1)$are not defined [23,24].

2.3. NeutroGroups generated by OffUninorms

The theory of NeutroAlgebras introduced by F. Smarandache generalizes the classical theory of Algebra and partial Algebras within the framework of Neutrosophic [17]. NeutroAlgebras continue to study algebraic structures based on ordered pairs formed by a set of elements and an operation. The main difference between NeutroAlgebras and the others is that they contain at least one NeutroAxiom , which is an axiom where there are two types of elements, those that satisfy the axiom and those that do not.

Continuing with the main idea of Neutrosophic, given an Algebra (axiom) <A>, there exists a triad (<A>, <NeutA>, <AntiA>) where the algebra (axiom) <A> is 100% true or true. For all elements, NeutroAlgebras (NeutroAxioms) <NeutA> are also admitted that are satisfied only by some of the elements, while AntiAlgebras (AntiAxioms) <AntiA> are not satisfied by any of the elements in the set.

This new approach to one of the most classical branches of mathematics poses a challenge to understanding these new ideas. Keep in mind that classical algebra is based on mathematical logic,

where only 100% true axioms are allowed.

A uninorm is a mapping that generalizes the definitions of t-norm and t-conorm. Where there is a neutral element, it is commutative, associative and non-decreasing with respect to each of the components. In [20] it is generalized to the field of Neutrosophic and in [25, 26] it is further generalized to the field of OffSets , which are sets defined outside the interval $[0,1]$or $[-1,1]$and are in general defined for intervals $[m,n]$where $m,n \in \mathbb{R}$, in particular for $[-n,n]$where the neutral is $e = 0$.

When configuring $n > 0$, you can define a NeutroGroup from Prospector's join function, which is the function used to aggregate elements from a known expert system obtained to model mining problems. This NeutroGroup contains within its structure the symbolic element I, which stands for indeterminacy.

Specifically, we'll use NeutroGroup with the operation $\oplus_5$ on the elements $G = \{-5,-4,-3,-2,-1,0,1,2,3,4,5,I\}$. This operation is commutative and associative, and the null element is 0. In addition, the following properties derived from the properties of the generator OffUninorm hold, considering only the truth component[27]:

- If $x, y < 0$then $x \oplus_5 y \leq min(x,y)$,
- If $x, y > 0$then $x \oplus_5 y \geq max(x,y)$,
- If $x < 0$and $y > 0$or if $x > 0$and $y < 0$, we have $min(x,y) \leq x \oplus_5 y \leq max(x,y)$.
- $\forall x \in G, x \oplus_5 0 = x$.
- $(-5) \oplus_5 5 = 5 \oplus_5 (-5) = I$.

In [17] it is summarized in the following Cayley table:

Table 1. Cayley table corresponding to $\oplus_5$. Source: [27].

$\oplus_5$	**-5**	**-4**	**-3**	**-2**	**-1**	**0**	**I**	**1**	**2**	**3**	**4**	**5**
-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	I
-4	-5	-5	-5	-5	-4	-4	-4	-4	-3	-2	0	5
-3	-5	-5	-4	-4	-4	-3	-3	-2	-1	0	2	5
-2	-5	-5	-4	-3	-3	-2	-2	-1	0	1	3	5
-1	-5	-4	-4	-3	-2	-1	-1	0	1	2	4	5
0	-5	-4	-3	-2	-1	0	I	1	2	3	4	5
I	-5	-4	-3	-2	-1	I	I	I	I	I	I	I
1	-5	-4	-2	-1	0	1	I	2	3	4	4	5
2	-5	-3	-1	0	1	2	I	3	3	4	5	5
3	-5	-2	0	1	2	3	I	4	4	4	5	5
4	-5	0	2	3	4	4	I	4	5	5	5	5
5	I	5	5	5	5	5	I	5	5	5	5	5

3. Methodology

Identification of Factors

Five key factors were identified that influence the legal effectiveness of urban wildlife protection:

- **F1. Constitutional Basis:** Evaluate whether the Constitution and fundamental laws explicitly recognize animal rights and the legal principles applicable to their protection.
- **F2. Specialized regulatory framework:** Measures the existence, quality and application of specific laws on animal welfare, abuse, responsible ownership, adoption, among others.

- **F3. Institutional Implementation**: Considers the State's capacity to apply the rules, including specialized bodies, allocated resources, and oversight mechanisms.
- **F4. Judicial Interpretation:** Analyze how courts interpret and apply animal protection regulations, taking into account the existence of relevant jurisprudence and consistent criteria.
- **F5. Citizen Participation:** Evaluates the level of social involvement in animal protection, including collective actions, complaints, volunteering, and public pressure on institutions.

Evaluation Scales

A discrete neutrosophic scale was used $S = \{s-5, \ldots, s5$ to represent the experts' qualitative assessments of each factor. In addition, an importance scale was incorporated $W = \{w-5, \ldots, w5\}$to assess the expert's knowledge of each factor.

Table 2. Linguistic meaning of the S scale

Worth	Linguistic meaning
s_{-5}	Extremely Low
s_{-4}	Very Low
s_{-3}	Low
s_{-2}	Somewhat Low
s_{-1}	Lower than High / Rather Low
s_0	As Low as High / Neutral
s_1	Higher than Low / Rather High
s_2	Somewhat High
s_3	High
s_4	Very High
s_5	Extremely High

Table 3. Linguistic meaning of the W scale

Worth	Linguistic meaning
w_{-5}	Extremely Insignificant / Extremely Unimportant
w_{-4}	Very Insignificant / Very Unimportant
w_{-3}	Insignificant / Unimportant
w_{-2}	Somewhat Insignificant / Somewhat Unimportant
w_{-1}	More Insignificant than Important / Rather Unimportant
w_0	Neutral
w_1	More Important than Insignificant / Rather Important
w_2	Somewhat Important
w_3	Important
w_4	Very Important
w_5	Extremely Important

Expert Evaluation

Three experts with experience in environmental law, animal protection, and institutional management were consulted. Each expert evaluated the five factors using a **linguistic triad** (truth, indeterminacy, falsity) and assigned a weighting based on their knowledge of the subject.

Table 4. Triadic evaluations and weights per expert

Expert	F1	F2	F3	F4	F5
e_1	(s_2, s_1, s_{-1}) (w_3)	(s_3, s_1, s_{-2}) (w_3)	(s_1, s_2, s_{-1}) (w_{-3})	(s_0, s_2, s_{-2}) (w_2)	(s_2, s_1, s_{-3}) (w_4)
e_2	(s_1, s_2, s_{-2}) (w_1)	(s_4, s_2, s_{-3}) (w_2)	(s_{-1}, s_3, s_0) (w_{-2})	(s_1, s_3, s−1) (w_3)	s_3, s_2, s_{-2}) (w_3)
e_3	(s_3, s_0, s_{-2}) (w_2)	(s_2, s_1, s_{-1}) (w_2)	(s_2, s_1, s_{-2}) (w_0)	(s_{-1}, s_4, s_0) (w_2)	(s_4, s_1, s_{-3}) (w_3)

Calculation of Neutrosophic Indices

The formula was used:

$$Ind_{ij} = \frac{r-s-t}{3} \quad (6)$$

where r, s, t are the numerical values corresponding to truth, indeterminacy and falsity.

Table 5. Calculated indices (Ind_{ij})

Expert	F1	F2	F3	F4	F5
e_1	1.833	2.667	1.5	1	2.667
e_2	2.167	2.333	-1.667	1.333	2.5
e_3	1.833	2.333	2	0.167	2.5

Weighted Average Evaluation Calculation

Each index was averaged with the expert's weight:

$$\boldsymbol{a_{ij}} = \frac{(\boldsymbol{ind_{ij}} + \boldsymbol{ind_{wij}})}{\mathbf{2}} \quad (7)$$

Table 6. Evaluations a_{ij}(weighted)

Expert	F1	F2	F3	F4	F5
e_1	2.4165	2.83	-0.75	1.5	3.3335
e_2	1.5835	2.165	-1.8335	2.1665	2.75
e_3	1.9165	2.1665	1	1.0835	2.75

Global Evaluation by Factor

The average is calculated:

$$a_j = round\left(\frac{1}{3}\sum a_{ij}\right) \quad (8)$$

Table 7. Overall evaluations by factor

Factor	a_j	Interpretation
F_1. Constitutional basis	2	Somewhat High
F_2. Regulatory framework	2	Somewhat High
F_3. Implementation inst.	-1	Lower than High / Rather Low
F_4. Judicial interpretation	2	Somewhat High
F_5. Citizen participation	3	High

Calculation of Global Legal Effectiveness

$A = \alpha_1 \oplus_5 \alpha_2 \oplus_5 \alpha_3 \oplus_5 \alpha_4 \oplus_5 \alpha_5 = (2 \oplus_5 2 \oplus_5 - 1 \oplus_5 2 \oplus_5 3) = 4$

Result: A = 4 → Very High

The applied neutrosophic analysis has revealed that the legal effectiveness in the protection of dogs and cats in urban environments presents an overall rating of " **Very High",** which suggests a normative structure in consolidation, with significant advances in regulatory aspects and social participation, but also with notable challenges in practical implementation.

4. Conclusions

The neutrosophic analysis applied to the evaluation of legal efficacy for urban animal protection, specifically dogs and cats in the Ecuadorian context, proves to be a valuable methodological tool for discerning the complexities and nuances of legal frameworks. The findings reveal a heterogeneous landscape of effectiveness: citizen participation (F5) stands out with a 'High' rating, establishing itself as the most solid pillar of the system. On the other hand, the constitutional foundation (F1), the specialized regulatory framework (F2), and judicial interpretation (F4) show 'Somewhat High' efficacy, suggesting an existing legal and doctrinal basis but with a still moderate impact in practice.

The main critical area identified is institutional implementation (F3), rated as 'Rather Low' , which highlights a significant gap between policy design and its effective execution by responsible bodies. These conclusions underscore the urgent need to strengthen institutional capacities and law enforcement mechanisms. The neutrosophic approach, by allowing an evaluation that captures uncertainty and expert perception, is consolidated as a useful instrument for precise diagnosis and the formulation of strategic recommendations aimed at improving animal protection in urban environments.

5. References

[1] Singer, P. Animal Liberation: A New Ethics for Our Treatment of Animals; HarperCollins: New York, NY, USA, 2009.
[2] Hadley, J. Animal Rights Advocacy and Urban Stray Populations. Ethics Environ. 2013, 18, 41–56.
[3] Favre, D. Animal Law: Welfare, Interests, and Rights; Wolters Kluwer: Alphen aan den Rijn, Netherlands, 2011.
[4] Arluke, A.; Lockwood, R. Understanding Cruelty to Animals. Soc. Anim. 1997, 5, 183–193.
[5] White, S. Companion Animals: Members of the Family or Legally Discarded Objects? UNSWLJ 2009, 32, 852–878.

[6] Baquero, M.; et al. (Autores completos no encontrados fácilmente) Stray Dog and Cat Population Management in Latin America. Animals 2021, 11, 1346.
[7] Egan, P.J.; Mullan, M. Urban Stray Cats: Challenges and Control Strategies. J. Feline Med. Surg. 2015, 17, 747–759.
[8] Schaffner, J. An Introduction to Animals and the Law; Palgrave Macmillan: London, UK, 2011.
[9] Giménez-Candela, T. The Evolution of Animal Welfare Legislation in Europe. J. Anim. Law 2020, 6, 1–20.
[10] Francione, G. Animals, Property, and the Law; Temple University Press: Philadelphia, PA, USA, 1995.
[11] Rowan, A. The State of Animal Welfare in Urban Environments. Anthrozoös 2021, 34, 481–494.
[12] Smarandache, F.; Leyva Vázquez, M.Y.; Cevallos-Torres, L.; Liberio Barco, L.J. Neutrosofía: Orígenes, aplicaciones y perspectivas en la lógica contemporánea. Neutrosophic Comput. Mach. Learn. 2025, 37, 1–10. DOI: https://zenodo.org/record/15200383
[13] Herrera, F.; Martínez, L. A 2-tuple fuzzy linguistic representation model for computing with words. IEEE Trans. Fuzzy Syst. 2002, 8, 746–752.
[14] Pérez-Teruel, K.; Leyva-Vázquez, M.; Espinilla, M. A linguistic software requirement prioritization model with heterogeneous information. In Proceedings of the 4th International Workshop on Knowledge Discovery, Knowledge Management and Decision Support (EUREKA 2013), Mazatlán, Mexico, 4–8 November 2013; Universidad de Occidente, Red Eureka Iberoamericana: Mazatlán, Mexico, 2013.
[15] Wang, J.; Wei, G.; Wei, Y. Models for green supplier selection with some 2-tuple linguistic neutrosophic number Bonferroni mean operators. Symmetry 2018, 10, 131. DOI: 10.3390/sym10050131
[16] Fan, J.; Yan, F.; Wu, M. GLDS method for multiple attribute group decision making under 2-Tuple linguistic neutrosophic environment. J. Intell. Fuzzy Syst. 2021, 40, 11523–11538.
[17] Smarandache, F. NeutroAlgebra is a Generalization of Partial Algebra. Int. J. Neutrosophic Sci. 2020, 2, 8–17.
[18] Smarandache, F.; Abdel-Basset, M.; Nordo, G.; Leyva-Vázquez, M.Y. Preface: Neutrosophic Sets and Systems {Special Issue: Mediterranean Conference on Three Decades of Neutrosophic and Plithogenic Theories and Applications (MeCoNeT 2024)}. Neutrosophic Sets Syst. 2024, 73, 59.
[19] Smarandache, F.; Al-Tahan, M. Neutroalgebra and antialgebra are generalizations of classical algebras. In Theory and Applications of NeutroAlgebras as Generalizations of Classical Algebras; IGI Global: Hershey, PA, USA, 2022; pp. 1–10.
[20] Caballero, E.G.; Leyva, M.; Ricardo, J.E.; Hernández, N.B. NeutroGroups Generated by Uninorms: A Theoretical Approach. In Theory and Applications of NeutroAlgebras as Generalizations of Classical Algebras; IGI Global: Hershey, PA, USA, 2022; pp. 155–179.
[21] Smarandache, F. Introducción a la Super-Hiper-Álgebra y la Super-Hiper-Álgebra Neutrosófica. Neutrosophic Comput. Mach. Learn. 2022, 20, 1–6. DOI: https://zenodo.org/record/6612313
[22] Salame Ortiz, M.A.; Jiménez Martínez, R.C.; Piñas Piñas, L.F. Neutrosophic Insights into Military Interventions: Assessing Legitimacy and Consequences in International Law. Neutrosophic Syst. Appl. 2024, 15, 46–57. DOI: 10.61356/j.nswa.2024.1512456
[23] Gaschnig, J. Prospector: an expert system for mineral exploration. In Introductory Readings in Expert Systems; Michie, D., Ed.; Gordon and Breach Science Publishers: New York, NY, USA, 1982; pp. 47–64.
[24] Silva Bernardo, A.S.; Ramón Ruffner, J.G.; Sánchez Cruz, D.; Padilla-Vento, P. Evaluation of the Impact of Government Audit on Quality Management, Based on Neutroalgebra Generated by the PROSPECTOR Function. Neutrosophic Sets Syst. 2024, 74, 20.
[25] Smarandache, F.; Quiroz-Martínez, M.A.; Ricardo, J.E.; Hernández, N.B.; Leyva Vázquez, M.Y. Application of neutrosophic offsets for digital image processing. Rev. Investig. Oper. 2020, 41, 603–611.
[26] Caballero, E.G.; Smarandache, F.; Leyva Vázquez, M. On neutrosophic offuninorms. Symmetry 2019, 11, 1136.
[27] Cruzaty, L.E.V.; Reynoso, A.M.R.; Hernández Bonilla, B.E. New Neutrosophic Sentiment Analysis Method Based on NeutroAlgebra for the Evaluation of Ethics in Companies. Neutrosophic Sets Syst. 2024, 70, 264–270.

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