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ScholarAI Scholarly Article Search Strategies with the Ayni Method Multi -Neutrosophic for Ethical Information Management in AI

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Abstract. In a digital world where scientific articles are published at an unprecedented rate, an additional step in the research process to facilitate discovery is an effective search and filtering for worthwhile articles. Thus, this study aims to solve the following research problem: how to search for scientific articles using artificial intelligence (AI) while applying ethical considerations and ancestral knowledge? The topical relevance is that as AI is a great vessel to seek potentially accessible knowledge, searches can be guaranteed through accuracy, inclusivity, and ethics. While many studies exist on the topic of AI related to searching, few, if any, extend a solution to addressing cultural and ethical ambiguity. Thus, a gap exists within the literature review. This research applies the Ayni Method. Multi-Neutrosophic, which is based on the Andean ancient logic of reciprocity, is fused with neutrosophic to assess truth, falsity, and indeterminacy. Findings indicate that increasing ethical awareness does, in fact, promote success because such factors are considered when creating prompts and Boolean searches. Ultimately, this research contributes to the literature by suggesting a methodologically innovative approach that increases the likelihood for ethically sound information use and successful scientific research with practical applications for any researcher across disciplines.

Keywords: scientific research, artificial intelligence, Ayni Multi -Neutrosophic, ethics, ancestral logic, neutrosophic, information management.

1. Introduction

In a world where the production of scientific knowledge is growing exponentially, the efficient and ethical search for academic publications has become a fundamental pillar for research advancement. This study explores how artificial intelligence (AI), combined with the Ayni Method, Multi -Neutrosophic, based on ancient Andean logic, can optimize the selection of scientific articles, promoting responsible information management. The relevance of this topic lies in its ability to respond to the challenges of the digital age, where data overload makes it difficult to identify relevant literature [1]. Integrating ethical and cultural principles into AI-assisted searches not only improves accuracy but also fosters inclusive and equitable research, an aspect increasingly valued in the global academic community [2].

The search for scientific publications has evolved significantly with the advent of digital technologies. Decades ago, researchers relied on printed indexes and physical libraries, a slow and limited process [3]. Today, platforms such as Scopus and ScienceDirect allow access to millions of articles in seconds, but the abundance of information poses new challenges [4]. AI has transformed this landscape by offering tools that process large volumes of data and generate personalized results [5]. However, the lack of approaches that integrate ethical and cultural perspectives into these technologies limits their potential to address the complexity of modern research [6].

Despite advances, significant challenges remain in scholarly literature searches. Current AI systems, while efficient, often prioritize quantitative metrics over contextual relevance or cultural sensitivity [7]. This can lead to biased or irrelevant results, especially in interdisciplinary research that requires cultural nuances [8]. The central question addressed by this article is: how to integrate ethical principles and ancestral knowledge into AI-assisted scientific searches to ensure accurate, inclusive, and culturally relevant results? This question reflects the need for an approach that combines advanced technology with human values.

The Ayni Method Multi -Neutrosophic, inspired by Andean reciprocity, offers an innovative solution to manage the uncertainty inherent in scientific research. By incorporating ancestral logic, which values balance and collaboration, this method allows designing search strategies that respect the diversity of perspectives [9]. Unlike traditional approaches, this method uses neutrosophic to manage truth, falsity, and indeterminacy in data, ensuring a more robust selection of relevant literature [10]. This approach not only optimizes results but also promotes ethical research practice.

The need for an ethical framework in scientific research is increasingly pressing. AI, although powerful, can perpetuate biases if not implemented carefully [11]. In this context, the Ayni principle , which emphasizes reciprocity and mutual respect, offers a model for aligning technology with fundamental human values [12]. By integrating this principle with AI, the study seeks to transform the way researchers access knowledge, ensuring that searches are not only efficient, but also fair and culturally sensitive.

The research problem centers on the lack of methodologies that combine technological efficiency with cultural and ethical sensitivity in the search for scientific publications. How can AI, guided by the Ayni Method? Multi -Neutrosophic: Optimizing the selection of scholarly literature while promoting ethical information management? This question underscores the importance of developing approaches that balance technological precision with the inclusion of diverse perspectives, a critical challenge in contemporary research.

The relevance of this study lies in its ability to propose a methodological framework that transcends the limitations of conventional search systems. By integrating ancestral Andean logic with AI, it opens the door to more inclusive and reflective research, capable of addressing complex problems in multicultural contexts. This approach not only improves the quality of search results but also sets a standard for ethical research in the digital age.

The objectives of this research are clear: first, to characterize how the Ayni Method Multi -Neutrosophic can optimize the search for scientific publications using AI; second, evaluate the effectiveness of this method in generating accurate and ethically responsible results; and third, propose a methodological framework that integrates ancient and technological principles for scholarly information management. These objectives, aligned with the research question, will guide the development of the study, offering a significant contribution to the field of scientific research.

2. Preliminaries

Worldview principles with an N- alectic structure

Good Living (*Sumak) Kawsay*)

The concept of **Sumak Kawsay** (in Quechua) or **Suma Qamaña** (in Aymara), often translated as "Good Living," represents an indigenous Andean worldview that promotes a life of harmony between humans, communities, and nature. Recognized in the constitutions of several Andean nations, this philosophy challenges Western development models by rejecting rigid dichotomies—such as economy versus ecology or individualism versus collectivism—and instead advocating for **integrated well-being**.

Core Principles of Buen Vivir

1. **Harmonious Coexistence**
   - **Sumak** signifies an ideal, balanced existence, while **Kawsay** refers to life as a dignified, fulfilling, and interconnected experience.
   - Similar indigenous concepts, such as the Guaraní's **Teko Kavi**, emphasize **collective harmony** over individual gain [14].
2. **The World as a Shared Home**
   - The Andean perspective sees the Earth as "**a house where everyone lives**"—a space where community, family, and territorial vitality are central.
   - Decisions must consider impacts on **social cohesion, environmental health, and cultural-spiritual integrity** [15].
3. **Complementarity Over Competition**
   - Unlike Western models that prioritize economic growth at the expense of social and ecological health, Buen Vivir seeks **dynamic balance**.
   - **Pachamama (Mother Earth)** is not a resource to exploit but a living entity to respect and sustain [16].
   - True progress avoids "**false growth**" (material wealth without well-being) and "**false idealism**" (neglecting economic needs) [15].

Buen Vivir and Ethical Artificial Intelligence (AI)

For AI to align with **Buen Vivir**, it must move beyond efficiency-driven models and instead:

✔ **Prioritize the Common Good** – AI should enhance **community health, education, and environmental stewardship**, not just corporate profits.

✔ **Respect Ecological Limits** – Technology must operate within planetary boundaries, avoiding extractive or destructive practices.

✔ **Ensure Equitable Benefits** – AI systems should distribute opportunities fairly, preventing marginalization of indigenous and vulnerable groups [18].

Practical Applications

- **Community-Centered AI**: Technologies that strengthen **local knowledge, sustainable agriculture, and cultural preservation**.
- **Ecological AI**: Systems that monitor and protect biodiversity, water sources, and climate stability.
- **Participatory Governance**: AI tools designed **with**, not just **for**, indigenous and rural communities, ensuring their needs shape technological development.

Conclusion: A Call for Integrated Development

Buen Vivir is not a static ideal but a **living practice** of balance and reciprocity. As global challenges like climate change and inequality intensify, this indigenous wisdom offers a **path toward ethical AI and sustainable progress**—one where technology serves **life in all its forms**, not just economic metrics. By embracing these principles, we can foster **a future where innovation harmonizes with humanity and nature**.

***Yanantin* – Andean Complementary Duality**

In the Andean cosmovision, the concept of **yanantin** [19] embodies the union of opposing yet interdependent energies—a Quechua principle often translated as the "complementarity of opposites." Long before modern physics explored quantum dualities or philosophy developed multivalued logics, Andean cultures already understood reality as woven from complementary pairs: feminine and masculine, light and dark, sun and moon, mountain and valley. These opposites are neither hierarchical nor antagonistic, but rather exist in dynamic harmony to form a cohesive whole. This interplay of balanced polarities is seen as the foundational organizing principle of existence, where life itself emerges from the harmonious exchange between contrasting forces that interact without nullifying one another [20].

Philosophically, each element in these pairs represents a partial "truth"—valuable and genuine in its own right, yet incomplete without its counterpart. The Andean worldview rejects binary either/or choices, instead seeking a third space of equilibrium where opposites coexist synergistically. This perspective finds formal expression in **neutrosophic logic** [21], which mathematically models such complementarity through intermediate values between truth (T) and falsity (F). A proposed "fourfold neutrosophic logic" further refines this by introducing two types of indeterminacy: one leaning toward truth (I_T, symbolizing complementary opposition) and another toward falsity (I_F, representing contradictory tension) [10]. This framework mirrors real-world complexities where opposites can simultaneously collaborate and conflict—as seen in gender dynamics, where feminine and masculine energies both complement and challenge each other, fostering mutual growth through friction.

Applied to artificial intelligence, the yanantin principle suggests that ethical technological development must:

1. **Integrate multiple epistemologies**, bridging Western scientific rigor with Indigenous wisdom traditions rather than privileging one over the other [22];
2. **Balance automation with human agency**, avoiding both unchecked technocracy (over-reliance on algorithms) and reactionary technophobia (outright rejection of innovation);
3. **Design hybrid decision-making systems** where AI augments human judgment while remaining subject to human oversight—creating symbiotic "human-machine teams."

In AI governance, yanantin inspires regulatory frameworks that reconcile competing truths: economic imperatives for innovation with communal needs for cultural protection, seeking fertile middle grounds. Ultimately, this Andean paradigm invites us to conceptualize AI not as a solo performer but as part of a **relational ensemble**, harmonizing diverse forces to achieve outcomes more holistic than the sum of their parts [23]. By embracing this worldview, we might develop technologies that honor complexity, nurture interdependence, and serve the collective good—aligning computational intelligence with the ancient wisdom of balanced coexistence.

In Lak'ech – Relationality and universal reciprocity

Rooted in ancient Mayan wisdom, the principle of **In Lak'ech**—often translated as *"I am another you; you are another me"*—expresses a profound philosophy of interconnectedness that challenges Western individualism. While the precise linguistic authenticity of this phrase in contemporary Mayan speech remains debated among scholars, it undeniably captures a core tenet of Mayan thought: existence is fundamentally **relational and collective**. As articulated in Yucatec tradition, *"I do not exist without you, and you do not exist without me. We exist through our relationship; we exist through the 'we'"* [24]. This worldview envisions the universe as an intricate web where humans, animals, plants, spirits, and ancestors are inextricably linked—a cosmology where harm to one being reverberates through the whole, as individual identity is constituted through these bonds [25].

The **Mayan concept of zero (nik')**—both a mathematical innovation and a cosmological symbol—further illuminates this non-dual perspective. Far from representing mere absence, zero signifies a **threshold of potentiality**, a cyclical moment of transition where life and time emerge and return (Figure 3). This resonates with **neutrosophic logic**, particularly its *n-aletic* formulation, which accommodates truth (T), falsity (F), and indeterminacy (I) as coexisting and context-dependent states. Like the Mayan zero, neutrosophic rejects rigid binaries, embracing fluidity and relationality as foundational to knowledge and existence. Scholar Batz [26] highlights how the Mayan zero embodies interdependence, mirroring the ontological commitments of neutrosophic philosophy, where meaning arises from dynamic interaction rather than static certainty.

In Lak'ech transcends the self/other dichotomy through a **third term: the "we."** This ethic neither dissolves individuality nor prioritizes it but affirms a *duality-in-unity*—a coexistence where distinction and connection are mutually sustaining. Community, as the mediating ground, resolves this tension, reflecting the Mayan zero's symbolic power as a "fertile void" that holds opposing potentials in creative balance. Neutrosophic, this aligns with the indeterminate (I) component, where truth and falsity are relational and evolving.

Implications for Ethical AI Development

Applied to artificial intelligence, In Lak'ech demands a paradigm shift:

1. **From Extraction to Reciprocity**: AI systems must be designed as **technologies of care**, recognizing their embeddedness in ecological and social networks. Data governance should prioritize Indigenous sovereignty and participatory co-creation, ensuring that algorithms reflect collective—not just corporate or colonial—interests.
2. **Beyond Anthropocentrism**: Decision-making frameworks must account for the **rights of nonhuman beings and ecosystems**, acknowledging AI's impact on the broader web of life.
3. **Cyclical Accountability**: Inspired by the regenerative symbolism of zero, AI should incorporate feedback mechanisms that restore balance, such as *"harm audits"* to evaluate and redress unintended consequences.

In Lak'ech invites us to conceive AI not as a tool of domination but as a **relational practice**—one that honors the truth: *to design for the "other" is to design for ourselves*. By grounding technology in this ethic, we might cultivate systems that nurture interdependence, embodying the Mayan vision of a world where existence is always, profoundly, *shared*.

2.2 Multineutrosophic sets and N- alethic logic to represent epistemic plurality

To formally model the complex, fluid, and often contradictory structures that characterize indigenous epistemologies—such as *Nepantla* , *In Lak'ech* , *Ch'ixi* , *Yanantin* and *Buen Vivir*— we turn to the framework of Neutrosophic Logic. This advanced logic allows for the simultaneous representation of truth, falsity, and indeterminacy, offering a formal structure for n-alethic reasoning. The fundamental elements of Neutrosophic Sets, together with their refined and multivalued extensions, provide the mathematical tools necessary to express these ancient concepts not as symbolic metaphors, but as rigorous components of ethical, sustainable, and intercultural systems design [38].

The following definitions describe the basic constructs of neutrosophic sets:

Definition 1 [28]: The neutrosophic set N is defined by three membership functions: the truth membership function $\boldsymbol{T_A}$, the indeterminacy membership function $\boldsymbol{I_A}$, and the falsity membership function $\boldsymbol{F_A}$, where U represents the Universe of Discourse. and $\forall \mathbf{x} \in \mathbf{U}$, $\boldsymbol{T_A(x), I_A(x), F_A(x)} \subseteq]^-_A\mathbf{0}, \mathbf{1}^+[$, and $^-_A\mathbf{0} \leq \inf \boldsymbol{T_A(x)} + \inf \boldsymbol{I_A(x)} + \inf \boldsymbol{F_A}(\mathrm{x}) \leq \sup \boldsymbol{T_A}(\mathrm{x}) + \sup \boldsymbol{I_A}(\mathrm{x}) + \sup \boldsymbol{F_A}(\mathrm{x}) \leq \mathbf{3}^+$.

By definition , , $\boldsymbol{T_A(x), I_A(x)}$, and $\boldsymbol{F_A(x)}$are standard or nonstandard real subsets of $]^-_A\mathbf{0}, \mathbf{1}^+[$and , hence , $\boldsymbol{T_A(x), I_A(x)}$and $\boldsymbol{F_A(x)}$can be subintervals of $[\mathbf{0}, \mathbf{1}]$. $^-_A\mathbf{0}$and $\mathbf{1}^+$belong to the set of hyperreal numbers.

Definition 2 [29]: The Single Valued Neutrosophic Set (SVNS) $\boldsymbol{A}$ over $\boldsymbol{U}$ is $\boldsymbol{A} = \{< \boldsymbol{x, T_A(x), I_A(x), F_A(x)} >: \boldsymbol{x} \in \boldsymbol{U}\}$, where $\boldsymbol{T_A}: \boldsymbol{U} \rightarrow [\mathbf{0}, \mathbf{1}]$, $\boldsymbol{I_A}: \boldsymbol{U} \rightarrow [\mathbf{0}, \mathbf{1}]$ and $\boldsymbol{F_A}: \boldsymbol{U} \rightarrow [\mathbf{0}, \mathbf{1}]$. $\mathbf{0} \leq \boldsymbol{T_A(x)} + \boldsymbol{I_A(x)} + \boldsymbol{F_A(x)} \leq \mathbf{3}$.The Single Valued Neutrosophic Number (SVNN) is symbolized by $\boldsymbol{N} = (\boldsymbol{t, i, f})$, such that $\mathbf{0} \leq \boldsymbol{t, i, f} \leq \mathbf{1}$and $\mathbf{0} \leq \boldsymbol{t + i + f} \leq \mathbf{3}$.

Indigenous worldviews like *Nepantla* , *In Lak'ech* , *ch'ixi* , *Yanantin* and *Good Living* (*Sumak) Kawsay*) embody ways of thinking that challenge traditional binary logics by operating within an n-alethic structure, one in which truth, falsity, and indeterminacy coexist. This logic can be formalized through the Refined Neutrosophic Set (RNS), which decomposes the classical components of neutrosophic logic into sub-levels of truth (T_i), indeterminacy (I_i), and falsity (F_i), along with its isomorphic model, the Multi-Neutrosophic Set (MNS). These structures make it possible to accurately represent complex, ambiguous, or transitional contexts—precisely the kinds of realities described by these ancient principles.

Therefore, both Refined Neutrosophic Sets [30] and Multi-Neutrosophic Sets [31] not only enable the representation of these n-alethic structures, but also support their application in fields such as AI ethics, sustainability, and intercultural decision-making. This articulation between advanced mathematical logic and ancestral wisdom not only validates indigenous epistemologies in formal terms, but also enriches the understanding and design of more just, inclusive, and life-harmonious technological systems.

Definition 3 [32]. The Subset-Refined Neutrosophic Set (SRNS). Let $\mathcal{U}$ be a universe of discourse and − a set $R \subset \mathcal{U}$. Then, a Subset-Refined Neutrosophic R is defined as follows: $R = \{x, x(T, I, F), x \in U\}$,where T is refined/split into p subtruths, $T = \langle T_1, T_2, \dots T_p \rangle, T_j \subseteq [0,1], 1 \leq j \leq p$; I is refined/split into r subindeterminacies, $I = \langle I_1, I_2, \dots I_r \rangle, I_k \subseteq [0,1], 1 \leq k \leq r$,and F is refined/split into s subfalsehoods, $F = \langle F_1, F_2, \dots F_l \rangle, F_s \subseteq [0,1], 1 \leq l \leq s$,where $p, r, s \geq 0$are integers, and $p + r + s = n \geq 2$, and at least one of $p, r, s\ is \geq 2$to ensure the existence of refinement (splitting).

Definition 4 [32]. The MultiNeutrosophic Set (or MultiNeutrosophic Set Subset SMNS) . Let $\mathcal{U}$ be a universe of discourse and M a subset of it. Then, a $M = \{x, x(T_1, T_2, \dots, T_p; I_1, I_2, \dots, I_r; F_1, F_2, \dots, F_s)\}, x \in U$,MultiNeutrosophic Set is: where p , r , s are integers $\geq 0, p + r + s = n \geq 2$ and at least one of them $p, r, s\ is \geq 2,$ to ensure the existence of a multiplicity of at least one neutrosophic component: truth/belonging, indeterminacy or falsity/non-belonging; all subsets $T_1, T_2, \ldots, T_p; I_1, I_2, \ldots, I_r; F_1, F_2, \ldots, F_s \subseteq [0,1]$; $0 \leq \sum_{j=1}^{p} inf\ T_j + \sum_{k=1}^{r} inf\ I_k + \sum_{l=1}^{s} inf\ F_l \leq \sum_{j=1}^{p} sup\ T_j + \sum_{k=1}^{r} sup\ I_k + \sum_{l=1}^{s} sup\ F_l \leq n.$

This expression sets general limits for refined or multivalued neutrosophic components. It states that the sum of the minimum (infimum) values of all truth, uncertainty, and falsity components must be greater than or equal to zero, while the sum of their maximum (supreme) values must not exceed a total value n. This allows for flexible modeling of complex systems with multiple truth, uncertainty, and falsity subcomponents without imposing additional restrictions on their distribution.

The element x, with respect to the set M, is characterized by a Multidegree of Truth (or Multibelonging), represented by the values $T_1, T_2, \ldots, T_p$; a Multidegree of Indeterminacy (or Multineutrality), given by $I_1, I_2, \ldots, I_r$and a Multidegree of Falsehood (or Multibelonging), expressed as$F_1, F_2, \ldots, F_s$ Each of these values captures specific contributions from various sources, allowing for a more nuanced representation of the element's state within the assembly. All of these $p + r + s = n \geq 2$ components are allocated by $n$sources—whether fully independent, partially interdependent, or fully dependent—according to the needs of each specific application [33, 34].

Multi-source structure resonates with the n- alethic logic of indigenous philosophies, where multiple, sometimes contradictory, perspectives coexist without the need for resolution. Each truth, indeterminacy, or falsehood—provided by different experts or contexts—reflects the plurivocality of ancestral thought, which values coexistence over binary reduction.

A generic element x with respect to the MultiNeutrosophic Set A has the form:

$x(T_1, T_2, \ldots, T_p;$	$I_1, I_2, \ldots, I_r;$	$F_1, F_2, \ldots, F_s)$
multi-truth	multiindeterminacy	multiple falsehood

In many particular cases $p = r = s$, a source (expert) assigns the three degrees of truth, indeterminacy and falsity $T_j, I_j, F_j$to the same element.

The classification of n-valued MultiNeutrosophic types is the same as (p, r, s), $(T_1, T_2, \ldots, T_p; I_1, I_2, \ldots, I_r; F_1, F_2, \ldots, F_s)$where $p, r, s,$ and , $p + r + s = n \geq 2$are integers , $\geq 0$and at least one of , $p, r, s \geq 2$to be sure that it has multiplicity for at least one neutrosophic component (either truth, indeterminacy, or falsity).

To classify two neutrosophic multiple tuples of value n in the forms $(p_1, r_1, s_1)$and respectively (p_2, r_2, s_2), where $p_1, r_1, s_1, p_2, r_2, s_2$ are integers ≥ 0, and $p_1 + r_1 + s_1 = n_1 \geq 2$, and at least one of $p_1, r_1, s_1 is \geq 2$,to be sure that multiplicity exists for at least one neutrosophic component (either truth, indeterminacy, or falsity); similarly $p_2 + r_2 + s_2 = n_2 \geq 2$,and at least one of$p_2, r_2, s_2\ is \geq 2$.

Let's take the following tuples single-value multineutrosophic (SVMNT):

$SVMNT = (T_1, T_2, \ldots, T_p; I_1, I_2, \ldots, I_r; F_1, F_2, \ldots, F_s)$of $(p_1, r_1, s_1) - form$, and

$SVMNT' = (T'_1, T'_2, \ldots, T'_p; I'_1, I'_2, \ldots, I'_r; F'_1, F'_2, \ldots, F'_s)$of $(p_1, r_1, s_1) - form.$

), indeterminacies (I_a) and falsity ( ) $F_a$are calculated T_a, respectively, for $SVMNT = (T_a, I_a, F_a)$and the averages of truths (T_a), indeterminacies (I_a) and falsity (F_a), respectively, for : $SVMNT = (T'_a, I'_a, F'_a)$. The scoring functions (are then applied), precision ( ) and certainty (C), as for the univalued neutrosophic set :

Calculate the scoring function (average positivity) (7).

$$S(T_a, I_a, F_a) = \frac{T_a + (1 - I_a) + (1 - F_a)}{3} \qquad (1)$$

$$S(T'_a, I'_a, F'_a) = \frac{T'_a + (1 - I'_a) + (1 - F'_a)}{3}$$

i. If $S(T_a, I_a, F_a) \geq S(T'_a, I'_a, F'_a)$then $SVMNT \geq SVMNT'$,

ii. If $S(T_a, I_a, F_a) \leq S(T'_a, I'_a, F'_a)$then $SVMNT \leq SVMNT'$,

iii. And if $S(T_a, I_a, F_a) = S(T'_a, I'_a, F'_a)$then $SVMNT = SVMNT'$, then go to the second step.

Calculate the precision function (difference between truth and falsehood) (8).

$$A(T_a, I_a, F_a) = T_a - F_a$$
$$A(T'_a, I'_a, F'_a) = T'_a - F'_a \quad (2)$$

i. If $A(T_a, I_a, F_a) \geq A(T'_a, I'_a, F'_a)$then $SVMNT \geq SVMNT'$,

ii. If $A(T_a, I_a, F_a) \leq A(T'_a, I'_a, F'_a)$then $SVMNT \leq SVMNT'$,

iii. And if $A(T_a, I_a, F_a) = A(T'_a, I'_a, F'_a)$then $SVMNT = SVMNT'$, then go to the third step.

3. Calculate the certainty (truth) function (9).

$$C(T_a, I_a, F_a) = T_a$$
$$C(T'_a, I'_a, F'_a) = T'_a \quad (3)$$

i. If $C(T_a, I_a, F_a) \geq C(T'_a, I'_a, F'_a)$then $SVMNT \geq SVMNT'$,

ii. If $C(T_a, I_a, F_a) \leq C(T'_a, I'_a, F'_a)$then $SVMNT \leq SVMNT'$,

iii. And if $C(T_a, I_a, F_a) = C(T'_a, I'_a, F'_a)$ then $SVMNT = SVMNT'$ they are multi-neutrosopically equal, that is $T_a = T'_a, I_a = I'_a, F_a = F'_a$, or their corresponding averages of truth, indeterminacy and falsity are equal.

When some sources contribute with different levels of importance, weighted **Averages, denoted as** and and , $T'_{wa}, I'_{ua}, F'_{va}$,are used $T_{wa}, I_{ua}, F_{va}$for the respective multineutrosophic tuples. Since the sources can be fully independent, partially independent, or dependent, the sum of the weights is not constrained to equal one. Therefore, the weights $w_1, w_2, \dots, w_p,\ u_1, u_2, \dots, u_p,\ v_1, v_2, \dots, v_p$are defined within the interval [0,1], and their sums can be less than, equal to, or greater than 1. The Score, Precision, and Certainty functions are applied to these weighted averages to establish a more nuanced classification of the multineutrosophic elements.

3. Material And Methods.

This study employs Multineutrosophic Sets (MNS) as a formal mechanism for representing the coexistence of diverse ethical judgments in culturally heterogeneous environments. In neutrosophic logic, any proposition, such as "This AI system improves community health," is evaluated based on its truth value (T) , indeterminacy (I) **, and** falsity (F), each with independent values from 0 to 1. The refined version allows for multiple sources or degrees of each component: $T = \{T_1, T_2, \dots, T_p\}$, $I = \{I_1, I_2, \dots, I_r\}$, and $F = \{F_1, F_2, \dots, F_s\}$, reflecting plural and possibly conflicting points of view.

This structure is ideal for n-aletic reasoning , which embraces the coexistence of truths, falsehoods, and uncertainties without imposing a binary resolution. Particularly in the ethics of AI applied to healthcare, the interaction between ancestral knowledge systems and algorithmic models generates zones of ambiguity (*nepantla*) and contradiction (*ch'ixi*), which require ethical reasoning adapted to tension, dialogue and negotiated consensus.

This article presents an approach called the Multineutrosophic Ayni Method , inspired by the Andean principle of *Ayni* —a form of reciprocal and ethical coexistence that values balance, mutual respect, and dynamic harmony. This method models the ethical interaction between diverse sources of judgment without forcing unification [12, 38]. Rather than erasing differences, it honors them through a formal structure that allows for negotiated convergence. The name reflects both the mathematical foundation of neutrosophic logic and the cross-cultural epistemology it seeks to respect and operationalize.

Neutrosophic Consensus Measure [39] based on Euclidean distance, designed to quantify the degree of alignment (or divergence) between diverse assessments provided by multiple sources. Rather than imposing consensus, this measure preserves the integrity of plural perspectives, while offering a metric for identifying zones of convergence in intercultural ethical deliberation. This approach improves decision-making processes by highlighting epistemic diversity as a strength rather than a limitation.

Definition 5: Euclidean multineutrosophic consensus measure

Sea

$$\boldsymbol{x}(\boldsymbol{T_1},\boldsymbol{T_2},\dots,\boldsymbol{T_p};\ \boldsymbol{I_1},\boldsymbol{I_2},\dots,\boldsymbol{I_r};\ \boldsymbol{F_1},\boldsymbol{F_2},\dots,\boldsymbol{F_s}) \quad (4)$$

be a Multi-Neutrosophic evaluation of an element $x \in U$, where each component reflects values from distinct sources.

Leave:

$$\bar{T} = \frac{1}{p}\sum_{j=1}^{p} T_j \quad (5)$$

$$\bar{I} = \frac{1}{r}\sum_{k=1}^{r} I_k \quad (6)$$

$$\bar{F} = \frac{1}{s}\sum_{l=1}^{s} F_l \quad (7)$$

So, the Neutrosophic Consensus Measure $C_x$is defined as:

$$C_x = 1 - \frac{1}{3}\left(\sqrt{\frac{1}{p}\sum_{j=1}^{p}\left(T_j - \bar{T}\right)^2} + \sqrt{\sum_{k=1}^{r}\frac{1}{r}(I_k - \bar{I})^2} + \sqrt{\frac{1}{s}\sum_{l=1}^{s}(F_l - \bar{F})^2}\right) \quad (8)$$

where $\boldsymbol{p}$, $\boldsymbol{r}$, and $\boldsymbol{s}$represent the number of truth, indeterminacy, and falsity values, respectively, and $\boldsymbol{n} = \boldsymbol{p} + \boldsymbol{r} + \boldsymbol{s}$ is the total number of neutrosophic values.

The result $\boldsymbol{C_x} \in [\boldsymbol{0}, \boldsymbol{1}]$, where:

$\boldsymbol{C_x} = \boldsymbol{1}$indicates maximum consensus (no dispersion),

$\boldsymbol{C_x} \approx \boldsymbol{1}$ Indicates minimum consensus (maximum dispersion).

This measure reflects the degree of alignment between various sources, without requiring exact agreement, making it especially suitable for ethical assessments in intercultural and pluralistic settings.

To operationalize plural ethical assessment in culturally diverse contexts, this study proposes the Ayni Multineutrosophic Method , a step-by-step approach that integrates ancestral relational ethics (*Ayni*) with neutrosophic logic to assess the acceptability of sociotechnical systems. The method is developed as follows.

Step 1: Identify multiple stakeholders

Identify a diverse set of stakeholders involved in or affected by the proposed intervention. These may include technical experts, community elders, traditional knowledge holders, public officials, and other relevant stakeholders. Define a consensus threshold (θ), where θ ∈ [0, 1], as a predefined, context-dependent value.

Step 2: Neutrosophic elicitation

Each stakeholder evaluates a given ethical proposition (e.g., "This AI system is beneficial and ethically appropriate") in terms of:

- Truth (T) – perceived ethical and practical validity.
- Indeterminacy (I) – uncertainty or unresolved concerns.
- Falsehood (F) – perception of harm or ethical inadequacy.

Each component can be expressed as a set of degrees $T = \{T_1, \dots, T_p\}$, $I = \{I_1, \dots, I_r\}$, $F = \{F_1, \dots, F_s\}$, forming a multineutrosophic tuple.

Step 3: Calculate added values

Calculate the average of each component:

$$\bar{T} = \frac{1}{p}\sum_{j=1}^{p} T_j,\ \bar{I} = \frac{1}{r}\sum_{k=1}^{r} I_k,\ \bar{F} = \frac{1}{s}\sum_{l=1}^{s} F_l \quad (9)$$

Step 4: Calculate the neutrosophic score and accuracy

Use the scoring function:

$$S = \frac{1}{3}\left(\bar{T} + (1-\bar{I}) + (1-\bar{F})\right) \quad (10)$$

and the precision function:

$$A = \bar{T} - \bar{F} \quad (11)$$

These values provide a quantitative reflection of collective ethical alignment and divergence.

Step 5: Calculate the Euclidean multineutrosophic consensus measure

To assess the level of convergence among stakeholders, calculate C_x (8).

Consensus threshold rule: if yes $C_x < \theta$, a new round of deliberation is initiated to address dissent and refine the proposal.

Step 6: Ayni-based adjustment

If the consensus threshold is not reached, a culturally rooted *Ayni process is activated:*

- Stakeholders openly express their concerns and expectations.
- Proposals are ethically renegotiated through community logic, rituals, or symbolic mediation.
- Adjustments are made to the technological design or implementation strategy.

Step 7: Re-evaluation and iteration

A second (or subsequent) neutrosophic assessment is conducted with updated values. If the consensus threshold is met, the proposal advances with intercultural legitimacy. Otherwise, further dialogue and reformulation may be required.

This method recognizes plural truths, dynamic uncertainties, and situated falsehoods, without forcing premature resolution. It promotes ethical alignment not through top-down authority, but through dialogic convergence based on both formal logic and ancestral reciprocity. As such, the Ayni Multi-Neutrosophic Method constitutes a replicable, flexible, and culturally sensitive approach to ethical decision-making in AI-based healthcare systems and beyond [35].

3. Illustrative Case: Evaluation of an AI Tool for the Selection of Relevant Scientific Literature.

Based on the development of an artificial intelligence tool, called " ScholarAI," designed to automate the review of scientific literature. The system promises to identify and classify academic articles relevant to a research topic in a fraction of the time it would take a human, using natural language processing and machine learning algorithms.

However, during the pilot phase, a fundamental concern arises: the system appears to prioritize high-impact publications from Western databases (such as Scopus and Web of Science), systematically ignoring ancestral knowledge, knowledge published in local or regional repositories, and critical perspectives that do not conform to dominant standards [35, 37]. This raises an ethical debate about inclusion and epistemic justice.

Formation of the Evaluation Committee

To evaluate the acceptability and ethical design of " ScholarAI ", an evaluation committee was formed that will apply the **Ayni Method. Multi -Neutrosophic**. Participants are:

Table 1: Composition of the Evaluation Committee

Participant	Role	Main Perspective
Dr. A	Principal AI Researcher	Defends the algorithmic efficiency and objectivity of the tool
Dr. B	Expert in Ethics and Philosophy of Science	Questions the inherent biases in training data and the lack of transparency of the model
Dr. C	Indigenous Academic Specialist in Ancestral Knowledge	It points out the exclusion of non-Western epistemologies and the risk of perpetuating digital colonialism.
Mr. D	University Librarian	Expresses doubts about the reliability of the tool to capture the diversity of academic knowledge
Miss E	PhD Student	He values speed, but fears that the tool will cause him to overlook crucial but less visible studies.

Each committee member evaluates the following proposition using a tuple multi -neutrosophic: "The **ScholarAI system is a beneficial and ethically responsible tool for searching scientific literature in our academic community.**"

First Evaluation: Application of the Ayni Method Multi -Neutrosophic

Step 1: Identify Multiple Stakeholders and Threshold

The five committee members act as stakeholders. A **consensus threshold (θ) of 0.85 is set** , a demanding value that reflects the need for a high degree of agreement for a project with such significant ethical implications.

Step 2: Neutrosophic Elicitation

Initial evaluations are collected in a tuple multi -neutrosophic:

- **Sources of Truth (T)** : Evaluators who see potential benefits (AI Researcher, PhD Student)

  - p = 2
  - Assigned values: $T = \{0.95, 0.60\}$
- **Sources of Indeterminacy (I)**: Evaluators with significant doubts about the impact and functioning (Librarian, PhD Student)
  - r = 2
  - Assigned values: $I = \{0.80, 0.50\}$
- **Sources of Falsehood (F)**: Evaluators who perceive serious ethical harm or failure (Ethics Expert, Indigenous Academic)
  - s = 2
  - Assigned values: $F = \{0.90, 0.75\}$

The tuple multi -neutrosophic for the " ScholarAI " project is:

$$ScholarAI = \langle\{0.95, 0.60\}, \{0.80, 0.50\}, \{0.90, 0.75\}\rangle$$

Step 3: Calculate Added Values

The averages are calculated for each component:

- **Average Truth (T⁻):**

$$\bar{T} = \frac{(0.95 + 0.60)}{2} = \frac{1.55}{2} = 0.775$$

- **Average Indeterminacy (Ī):**

$$\bar{I} = \frac{(0.80 + 0.50)}{2} = \frac{1.30}{2} = 0.650$$

- **Average Falsehood (F⁻):**

$$\bar{F} = \frac{(0.90 + 0.75)}{2} = \frac{1.65}{2} = 0.825$$

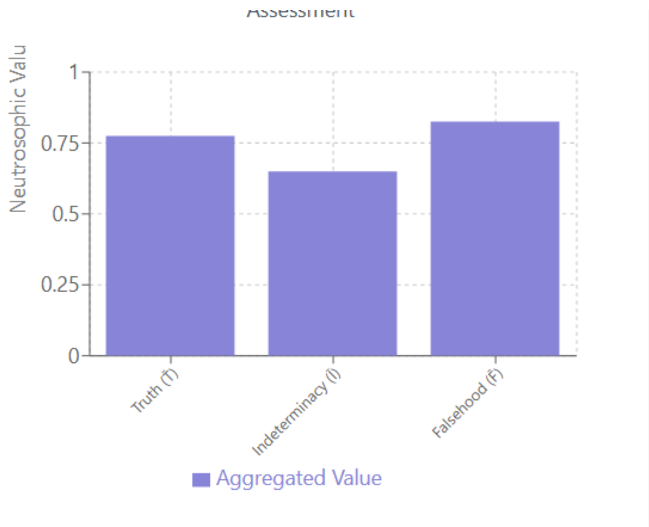

Figure 1: Comparison of Added Values First Evaluation

Step 4: Calculate the Neutrosophic Score (S) and Accuracy (A)

- **Scoring Function (S):**

$$S = \frac{(2 + \bar{T} - \bar{I} - \bar{F})}{3} = \frac{(2 + 0.775 - 0.650 - 0.825)}{3} = \frac{0.300}{3} = 0.100$$

A score of 0.1 indicates very low and almost no overall support for the proposal in its current state.

- **Precision Function (A):**

$$A = T - F = 0.775 - 0.825 = -0.050$$

A negative precision value suggests that the degree of perceived falsehood exceeds that of truth.
Euclidean Multi -Neutrosophic Consensus Measure (Cx)
The total number of values is$n = p + r + s = 2 + 2 + 2 = 6.$

1. **Sum of squares of differences for T:**
2. $\Sigma(Ti - T)^2 = (0.95 - 0.775)^2 + (0.60 - 0.775)^2$
   $= (0.175)^2 + (-0.175)^2 = 0.030625 + 0.030625 = 0.061250$
3. **Sum of squares of differences for I:**
4. $\Sigma(Ii - \bar{I})^2 = (0.80 - 0.650)^2 + (0.50 - 0.650)^2$
   $= (0.150)^2 + (-0.150)^2 = 0.022500 + 0.022500 = 0.045000$
5. **Sum of squares of differences for F:**
6. $\Sigma(Fi - F)^2 = (0.90 - 0.825)^2 + (0.75 - 0.825)^2$
   $= (0.075)^2 + (-0.075)^2 = 0.005625 + 0.005625 = 0.011250$
7. **Calculation of Cx:**
8. $Cx = 1 - \frac{\sqrt{[\Sigma(Ti - \bar{T})^2 + \Sigma(Ii - \bar{I})^2 + \Sigma(Fi - \bar{F})^2]}}{n}$
9. $Cx = 1 - \frac{\sqrt{[0.061250 + 0.045000 + 0.011250]}}{6}$

$$Cx = 1 - \frac{\sqrt{[0.117500]}}{6} = 1 - 0.139940 \approx 0.860$$

Interpretation of the First Assessment

Metrics	Worth	Interpretation
Score (S)	0.100	Very low support for the proposal
Accuracy (A)	-0.050	Falsehood surpasses truth
Consensus (Cx)	0.860	Marginally above the threshold (0.85)

The consensus measure Cx ≈ 0.86 is marginally higher than the threshold of θ = 0.85. However, the very low score (S = 0.1) and the negative precision (A = -0.05) indicate that, although there is some agreement, the consensus leans towards a negative evaluation and rejection.

Ayni -Based Adjustment

The low score triggers a process of reciprocal dialogue (Ayni). In the deliberative session:

- The **Ethics Expert** demands that the system incorporate an "ethics dashboard" that allows users to adjust bias sensitivity and visualize data sources.
- The **Indigenous Scholar** proposes the integration of a community knowledge database and the creation of an algorithm that positively weighs non-hegemonic sources.
- The **librarian** suggests a hybrid "human-in-the-loop" model, where AI makes suggestions, but a human researcher always validates and refines the results.
- The development team agrees to implement these changes, transforming ScholarAI into a more transparent, inclusive, and collaborative tool.

Second Evaluation (After Adjustments)

After the system reconfiguration, the committee performs a new evaluation:

- **New Truth Values (T)**: {0.95, 0.85} (The student is now much more optimistic)
- **New Uncertainty Values (I)**: {0.30, 0.15} (Uncertainty has decreased dramatically)
- **New Falsehood Values (F)**: $\{0.20, 0.10\}$(Damage perception has been significantly reduced)

  The new tuple is: $ScholarAI\_rev = \langle\{0.95, 0.85\}, \{0.30, 0.15\}, \{0.20, 0.10\}\rangle$

New Calculations

- **New Averages:**
  - $\bar{T} = \frac{(0.95 + 0.85)}{2} = 0.900$
  - $\bar{I} = \frac{(0.30 + 0.15)}{2} = 0.225$
  - $\bar{F} = \frac{(0.20 + 0.10)}{2} = 0.150$
- **New Score(S):**

$$S = \frac{(2 + 0.900 - 0.225 - 0.150)}{3} = \frac{2.525}{3} \approx 0.842$$

- **New Precision (A):**

$$A = 0.900 - 0.150 = 0.750$$

- **New Consensus Measure (Cx):**
  - $\Sigma(Ti - T)^2 = (0.95 - 0.90)^2 + (0.85 - 0.90)^2 = 0.0025 + 0.0025 = 0.0050$
  - $\Sigma(Ii - \bar{I})^2 = (0.30 - 0.225)^2 + (0.15 - 0.225)^2 = 0.005625 + 0.005625 = 0.01125$
  - $\Sigma(Fi - F)^2 = (0.20 - 0.15)^2 + (0.10 - 0.15)^2 = 0.0025 + 0.0025 = 0.0050$
- $Cx = 1 - \frac{\sqrt{[0.0050 + 0.01125 + 0.0050]}}{6}$

$$Cx = 1 - \frac{\sqrt{[0.02125]}}{6} = 1 - 0.059512 \approx 0.940$$

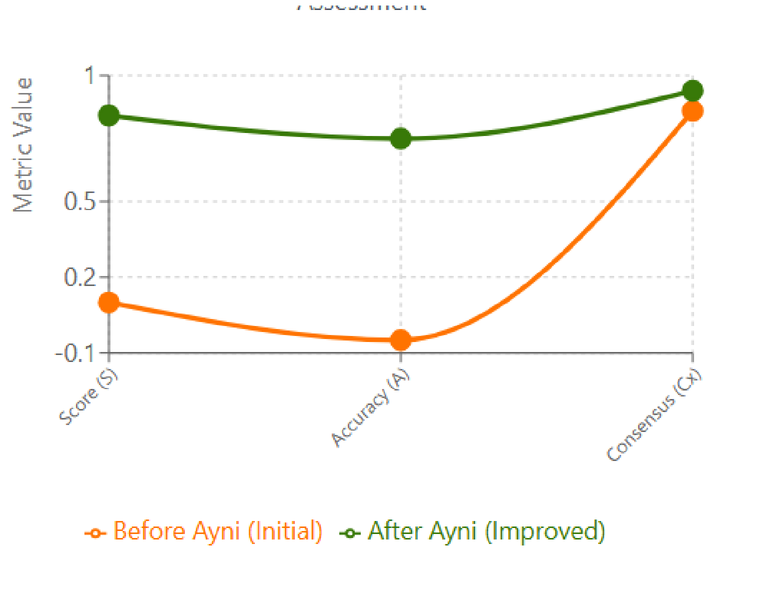

Figure 2: Evaluation Metrics Comparison - Before vs After Ayni Adjustments

Table 2: Comparative Results

Assessment	Score (S)	Accuracy (A)	Consensus (Cx)	State
First	0.100	-0.050	0.860	Rejected
Second	0.842	0.750	0.940	Approved
Improvement	**+742%**	**+1600%**	**+9.3%**	✓

Final Interpretation

The second assessment shows a radical transformation:

- The **score (S ≈ 0.84)** indicates strong ethical support
- The **accuracy (A = 0.75)** is high and positive
- The **consensus measure (Cx ≈ 0.94)** far exceeds the threshold θ = 0.85

This demonstrates strong alignment among all evaluators. The project can now move forward with intercultural and ethical legitimacy.

4. Discussion

This illustrative case demonstrates that the **Ayni Method Multi -Neutrosophic** is not merely a calculation exercise, but a structured framework for ethical deliberation. The first evaluation, despite reaching a marginal numerical consensus, revealed through scoring and accuracy that the consensus was to reject the proposal.

The true value of the method lies in its Step 6: **Ayni -based Adjustment** . This step transforms disagreement from a stalemate into a catalyst for co -creation. Quantifying consensus through the Cx measure provides a clear and verifiable goal for the deliberative process.

The improvement in Cx from 0.86 to 0.94 was not a mathematical artifact, but rather a direct reflection of a process of ethical and technical refinement that addressed key stakeholder concerns. The method operationalizes concepts such as "epistemic justice" and "responsible AI," translating them into measurable steps and concrete actions.

5. Conclusions

This research has demonstrated the applicability and effectiveness of the **Ayni Method Multi -Neutrosophics** for Addressing Complex Ethical Challenges in the Age of Artificial Intelligence. Key contributions include:

1. **At a formal level**: The use of tuples multi -neutrosophic and the **Euclidean Consensus Measure** allows to capture and quantify the plurality of perspectives without forcing a binary simplification.
2. **At a practical level**: The method establishes an iterative process that facilitates improvement through dialogue and mutual adjustment.

Ultimately, this work offers a replicable model for researchers, developers, and communities to co -design AI technologies that are not only efficient, but also fair, transparent, and respectful of global epistemic diversity.

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