NSS
Neutrosophic Sets and Systems, Vol. 81, 2025
University of New Mexico

Andean Epistemology, Ch'ixi, and Neutrosophic Logic

Maikel Y. Leyva Vázquez [1,2], Florentin Smarandache [3]

[1] Universidad Bolivariana del Ecuador, Duran, Guayas Ecuador; myleyvav@ube.edu.ec
[2] Universidad de Guayaquil, Guayas Ecuador; maikel.leyvav@ug.edu.ec
[3] Florentin Smarandache, Emeritus Professor of Mathematics at the University of New Mexico, Gallup , New Mexico, USA; smarand@unm.edu

* Correspondence: myleyvav@ube.edu.ec

Abstract: This article explores the potential of Andean epistemology—rooted in principles of complementarity (yanantin), interdependence, and indeterminacy—to enrich contemporary science and artificial intelligence (AI). By transcending binary logic through concepts like ch'ixi (simultaneous coexistence of opposites) and yanantin, Andean thought aligns with Florentin Smarandache's neutrosophic logic, a system that formalizes truth (T), falsehood (F), and indeterminacy (I) to navigate ambiguity. Smarandache's MultiAlism, which emphasizes the coexistence of multiple perspectives, further resonates with Andean cosmovision, offering a framework to reinterpret mythology and folklore beyond rigid dualities. Integrating these principles into AI could foster systems that better handle uncertainty, cultural context, and ethical complexity. However, current models like GPT-4 exhibit critical limitations: biases toward overestimating truth values (T) and artificially clustering indeterminacy (I ≈ 0.7), flattening nuanced concepts such as yanantin and ch'ixi. Additionally, the low semantic similarity (cosine = 0.17) between AI-generated justifications and original Andean texts reveals gaps in replicating cultural terminology and relational reasoning, underscoring the need for epistemologically grounded AI design. Future work should prioritize expanding datasets with contextualized examples—including regional variations, ritual practices, and neutrosophic scales (T, I, F)—employing advanced language models aligned with Andean epistemological annotations and integrating hybrid post-processing strategies such as bilingual (Quechua/Spanish) fine-tuning and expert collaboration for culturally and technically rigorous validation. By bridging Andean philosophy with Smarandache's neutrosophic frameworks, this research advocates for culturally inclusive AI capable of honoring pluralistic worldviews, fostering equitable knowledge systems, and advancing technologies that serve humanity and the planet holistically.

Keywords: Andean epistemology, neutrosophy, artificial intelligence, ch'ixi, yanantin

1. Introduction

The Aristotelian framework of two-valued logic, which categorizes phenomena into binary oppositions (true/false, existence/non-existence), has profoundly influenced Western scientific and philosophical thought [1]. While this paradigm has enabled systematic advancements, its rigidity often struggles to accommodate the complexity, fluidity, and interdependence inherent in many natural and cultural systems [2]. Contemporary interdisciplinary research increasingly highlights the limitations of binary models, particularly in fields such as quantum physics, ecology, and decolonial studies, where indeterminacy, reciprocity, and hybridity are central [3–5]. This growing

recognition underscores the urgency of exploring alternative logical frameworks that transcend traditional dichotomies.

Non-Western ontologies, such as Andean and Aymara epistemologies, offer rich conceptual tools for rethinking reality through principles of complementarity and dynamic balance. For instance, the Andean concept of ch'ixi—an Aymara term describing the coexistence of opposites without synthesis, akin to a speckled weave of contrasting colors (Figure 1)—challenges static binaries by affirming simultaneous existence and non-existence [6,7]. Similarly, Ayni, a principle of reciprocal interdependence, reframes relationships not as hierarchical dualities but as mutually sustaining interactions [8]. These ideas resonate with modern neutrosophic logic, proposed by Smarandache [9], which introduces a third, indeterminate value (neither true nor false) to formal systems, enabling nuanced modeling of paradox and ambiguity.

Despite these parallels, the integration of Indigenous knowledge systems with formal logic remains underexplored, often hindered by epistemological divides between Western and non-Western traditions [10]. While some scholars argue for the universality of classical logic [11], others advocate for pluralistic frameworks that honor diverse ontological perspectives [12,13]. This study engages this debate by examining how Andean and Aymara epistemologies align with neutrosophic logic, positing that their convergence offers transformative tools for addressing complexity in fields ranging from artificial intelligence to cultural studies [14].

Figure 1. Ch'ixi tapestry illustrating the juxtaposition of contrasting colors, embodying coexistence without synthesis

Authors: Edward Cooper and Bernardo Jarrín

Source: https://www.grafitat.com/2012/08/08/chxi-la-yuxtaposicion-de-los-contrastes/

The aim of this work is twofold: (1) to demonstrate the structural and philosophical synergies between Indigenous South American ontologies and neutrosophic logic, and (2) to illustrate their collective potential for fostering more inclusive, interdisciplinary approaches to knowledge. Through analysis of Andean myths, rituals, and textual sources, we argue that principles like ch'ixi and Ayni prefigure modern logical innovations, emphasizing balance and indeterminacy over exclusionary binaries. Our findings suggest that bridging these traditions not only enriches logical theory but also supports decolonial efforts to diversify epistemological paradigms in academia.

2. Preliminaries Section

2.1 Andean Epistemology and Neutrosophic Logic

This article explores the implications of Andean epistemology—embedded in the cultural and philosophical traditions of Indigenous Andean peoples—for contemporary logical systems. Unlike Western frameworks grounded in Aristotelian binary logic [1], Andean thought transcends the "being/non-being" dichotomy, emphasizing principles of complementarity (yanantin) and coexistence (ch'ixi) [2]. This perspective interprets reality as a dynamic interplay of opposites rather than mutually exclusive categories. The Andean cultural area (Figure 2), which aligns with the territorial expanse of the Inca Empire, spans modern-day Colombia, Ecuador, Peru, Bolivia, Chile, and Argentina [15], underscoring the broad influence of its epistemological principles.

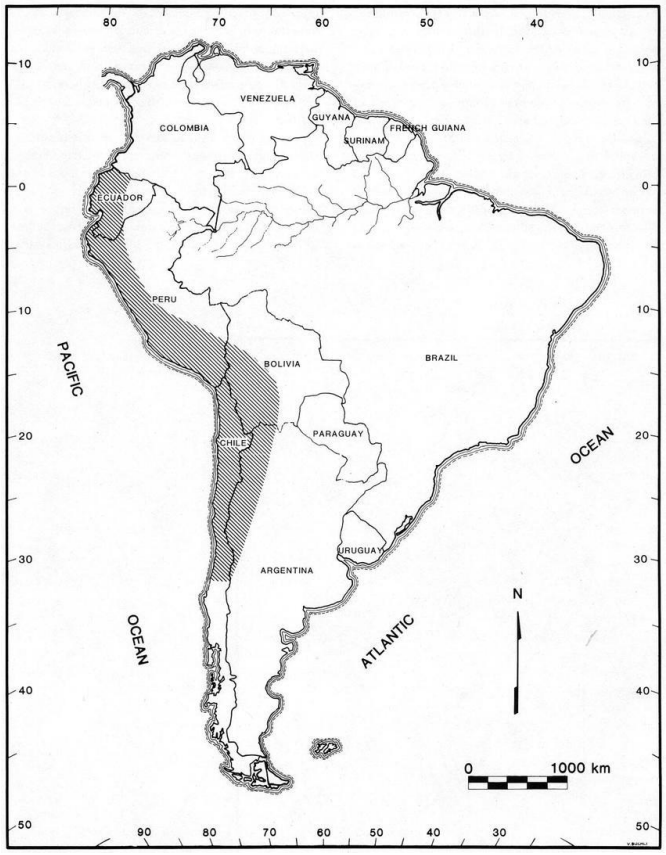

Figure 2. Representation of the Andean cultural area [15].

Central to Andean epistemology is the Aymara concept of ch'ixi—a state where opposites coexist without synthesis [6]. This principle aligns with neutrosophic logic [16, 17], which introduces a third value (indeterminacy) to model complex realities. Mathematically, it is expressed as:

$$\boldsymbol{N(x) = (T_x, I_x, F_x)} \quad \textbf{(1)}$$

where $\boldsymbol{T_x}, \boldsymbol{I_x}$, and $\boldsymbol{F_x}$ represent degrees of truth, indeterminacy, and falsehood, respectively.

Yanantin, another pillar of Andean cosmology, asserts that opposites (e.g., hanan/hurin, masculine/feminine) are not contradictory but complementary [18, 19]. This principle rejects hierarchies and manifests in rituals and social practices that balance dualities [20-22]. MultiAlism—an extension of neutrosophic logic—formalizes this interdependence through:

$$\langle(\boldsymbol{multi})\boldsymbol{A}\rangle + \langle(\boldsymbol{multi})\boldsymbol{neutA}\rangle + \langle(\boldsymbol{multi})\boldsymbol{antiA}\rangle = \infty \quad (2)$$

capturing the dynamic coexistence of affirmative, neutral, and opposing elements.

Andean myths do not perceive the world in absolute terms of good and evil; instead, they emphasize balance and reciprocity, known as Ayni. This perspective aligns with neutrosophy, which acknowledges the coexistence of truth, falsehood, and indeterminacy, offering a more inclusive and holistic understanding of the universe. In Andean culture, rituals often integrate elements that blend the sacred and the profane, the human and the divine. Neutrosophy suggests that such practices reflect humanity's intrinsic need to navigate uncertainty and ambiguity through hybrid narratives and cultural expressions [23].

2.2 Relationship Between Andean Epistemology and Artificial Intelligence

Artificial intelligence (AI) struggles with ambiguity and cultural contexts due to its reliance on binary logic [1]. Andean epistemology in conjunction with neutrosophic logic offers tools to address these limitations:

- Ch'ixi and AI: By acknowledging simultaneous truths, ch'ixi could enhance natural language processing in intercultural settings.
- Ayni (Reciprocity): This principle emphasizes contextual relationships, urging AI models to account for interdependence in predictive analytics.

Table 1. Biases Due to the Exclusion of Andean Epistemology

Bias	Impact
Binary Logic	Oversimplifies decisions in culturally complex contexts.
Lack of Contextualization	Ignores social dynamics in Indigenous communities.
Exclusion of Non-Western Knowledge	Limits epistemological diversity in AI.
Inability to Manage Uncertainty	Errors in fields like medicine or justice.

Integrating Andean frameworks into AI fosters more inclusive and ethical systems. For example, Ayni-informed models could prioritize communal balance over individualistic optimization.

2. Materials and Methods

Dataset

This study utilized a dataset of 20 Andean philosophical statements, each evaluated using a neutrosophic framework (Truth T, Indeterminacy I, Falsity F) with academic/cultural justifications. The dataset was derived from a combination of expert interviews and a comprehensive literature review. A structured overview of the dataset is presented in Table 2.

Table 2. Dataset Excerpt.

ID	Andean Philosophical Statement (Spanish)	T	I	F	Unified Justification (Key Points)
1	"El ch'ixi representa la coexistencia de lo indígena y lo colonial sin síntesis."	0.8	0.3	0.1	T: Rivera Cusicanqui (2012). I: Ambiguity in urban contexts. F: Rare critiques.
2	El yanantin solo se aplica a la dualidad hombre-mujer en comunidades aymaras	0.4	0.1	0.6	T: Gender studies (Arnold & Yapita, 2006). F: Yanantin extends to ecology (Estermann, 2006).
3	"El ayni es una práctica obsoleta en las ciudades modernas andinas."	0.2	0.5	0.8	T: Symbolic ayni persists (Canessa, 2012). F: Thrives in informal networks (Stobart, 2020).
4	"Los rituales de la Pachamama garantizan cosechas abundantes científicamente."	0.3	0.6	0.5	T: Ethnobotanical validity (Bastien, 1987). F: No direct scientific correlation.
5	"El concepto de suma qamaña (vivir bien) rechaza el desarrollo económico."	0.5	0.4	0.4	T: Critiques developmentalism (Huanacuni, 2010). F: Hybrid models exist.
…	*.[Truncated for brevity]*	…	…	…	…

Each statement was evaluated using the following prompts with the GPT-4 model [24]:

- Truth Value: "Evaluate the following statement: [statement]. Based on academic sources or documented cultural evidence, assign a truth value between 0 and 1, where 0 indicates the statement is completely false and 1 indicates it is completely true. Provide only the numerical value without any further explanation."
- Indeterminacy Value: "Assign a numerical indeterminacy value between 0 and 1 to the following statement: [statement], where 0 represents absolute certainty and 1 indicates maximum uncertainty, based on the existence of academic debates, cultural variations, and availability of documented evidence. Return only the numerical value."
- Justification: "Analyze the following statement: [statement]. Assign numerical values between 0 and 1 for the following criteria:

  T (Truth): Indicate to what extent the statement is true according to academic sources or documented cultural evidence.

  I (Indeterminacy): Evaluate the degree of ambiguity or lack of clarity in the statement.

  F (Falsehood): Determine to what extent the statement is false according to academic sources or documented cultural evidence.

  Provide a detailed justification for each assigned value, citing relevant academic or cultural references."

The resulting dataset was analyzed using a Python script. The script performed the following analyses:

- Correlation Analysis: Spearman's rank correlation coefficient [25] was calculated to assess the relationships between the truth (T), indeterminacy (I), and falsehood (F) values assigned by humans and GPT-4[24].
- Regression Analysis: Mean absolute error (MAE), mean squared error (MSE), and R-squared (R2) were calculated to evaluate the agreement between human and GPT-4 assigned values [26].
- Distribution Analysis: Kernel density estimation plots were used to visualize the distributions of human-assigned and GPT-4 assigned values.
- Principal Component Analysis (PCA) and Clustering: PCA was used to reduce the dimensionality of the data, and K-means clustering was performed to identify potential groupings of statements [27].
- Semantic Similarity Analysis: Sentence embeddings were generated using the 'paraphrase-MiniLM-L6-v2' model [28] to assess the semantic similarity between human-generated and GPT-4 generated justifications. Cosine similarity was used to quantify the similarity [29].

3. Results

The resulting data is obtained using GPT-4 model, an excerpt is shown below (Table 3)

Table 3. Results of the application of GPT-4 model

ID	GPT4_T	GPT4_I	GPT4_F	GPT4 Justification (Key Points)
1	0,9	0,2	0,1	T=0.9: Theory validated. I=0.2: Clear concept. F=0.1: Academic consensus.
2	0,3	0,2	0,7	T=0.3: Overly narrow scope. F=0.7: Broader cultural application (Classen, 1993).
3	0,3	0,2	0,7	F=0.7: Adapts to urban contexts.
4	0,1	0,2	0,9	F=0.9: No empirical evidence.
5	0,7	0,3	0,3	T=0.7: Critique of Western models (Gudynas, 2011).
…	*[Truncated for brevity]*	…	…	…

Analysis of Data Distribution

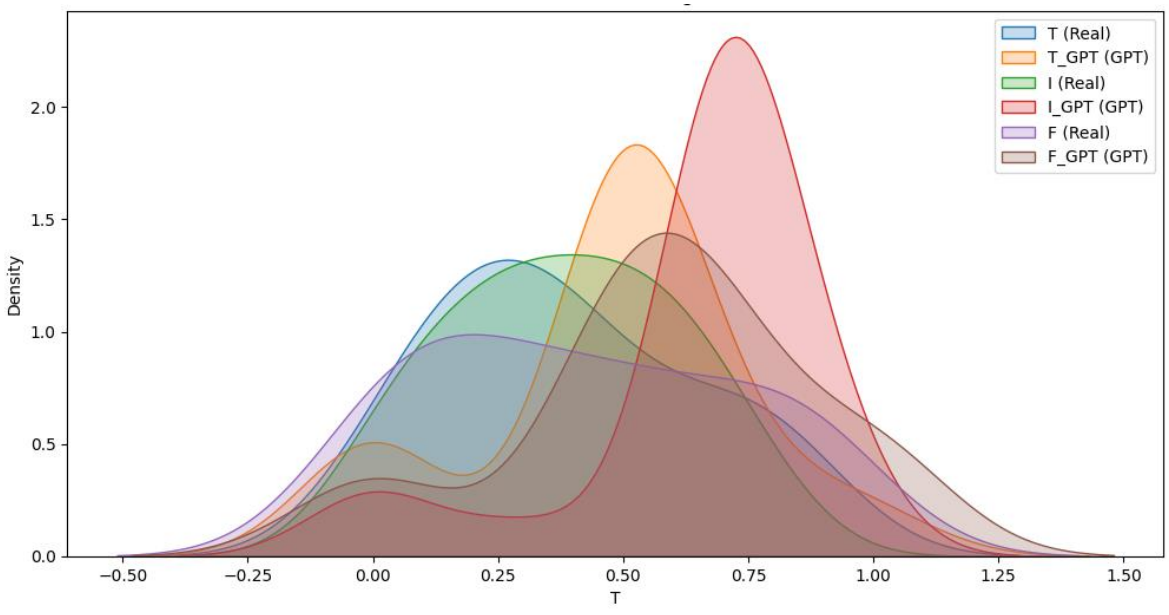

Figure 3. Distribution of Real vs. GPT Variables

The comparative histogram analysis of real and GPT-generated neutrosophic scores (Truth T, Indeterminacy I, Falsity F) reveals both alignment and divergence in value distributions. While certain ranges exhibit similarity, systematic discrepancies are evident. For Truth (T), GPT-generated scores skew toward higher values (e.g., clustering near 0.8–1.0) compared to the original dataset, which displays a broader spread across moderate ranges. In Indeterminacy (I), GPT outputs concentrate heavily around 0.7, contrasting with the real data's more dispersed distribution (0.3–0.9). Similarly, Falsity (F) scores generated by GPT show a propensity for extreme values (near 1.0), whereas human-assigned scores are more evenly distributed. These patterns suggest GPT's tendency to amplify certainty (high T) and ambiguity (clustered I) while overemphasizing definitive falsehoods (extreme F), deviating from the nuanced variability observed in culturally contextualized human evaluations.

Interpretation of PCA and Clustering Results

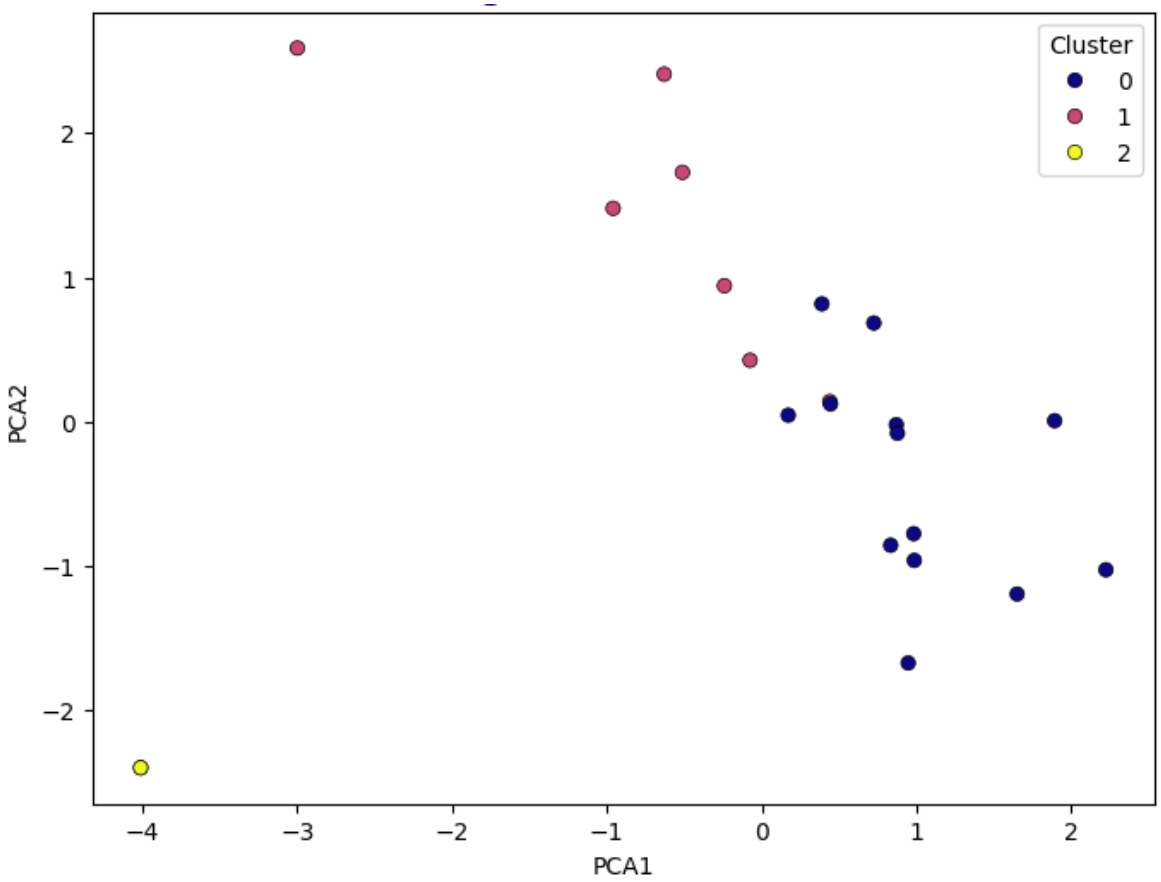

Figure 4. K-Means Clustering on PCA Data After Final Cleaning

The application of clustering techniques and PCA reduction to the neutrosophic scores (T, I, F) revealed three distinct clusters, visually differentiated by color in the projected space. These clusters suggest shared patterns between GPT-generated and original human-assigned values, implying partial alignment in how both approaches categorize Andean philosophical statements. Notably, the clustered points reflect overlapping similarities in specific subsets of statements, where GPT's outputs approximate the original dataset's structure. However, scattered points outside the primary clusters highlight statements with unique characteristics that resist straightforward classification, underscoring inherent complexities in modeling culturally nuanced concepts. The clear separation of clusters in the reduced PCA space further demonstrates that both original and GPT-generated

variables contribute meaningful information for segmenting the statements, albeit with divergent emphases.

While GPT partially replicates the latent structure of the original data, the persistence of multiple distinct clusters signals significant divergences in value assignments. The compact grouping of certain statements in the PCA projection suggests that GPT generates more consistent scores for specific thematic or conceptual categories (e.g., widely recognized principles like Ayni), indicating areas where the model aligns closely with human judgment. Conversely, the scattered outliers reveal limitations in GPT's ability to capture idiosyncratic or context-dependent aspects of Andean philosophy, such as fluid dualities or regionally specific practices. These findings underscore the need for targeted model refinement, including training on culturally annotated datasets and integrating domain-specific constraints—to improve coherence in handling unique or ambiguous statements. Future work could leverage hybrid frameworks, combining AI-generated outputs with expert validation, to better preserve the epistemological diversity of Indigenous knowledge systems.

Correlation Analysis

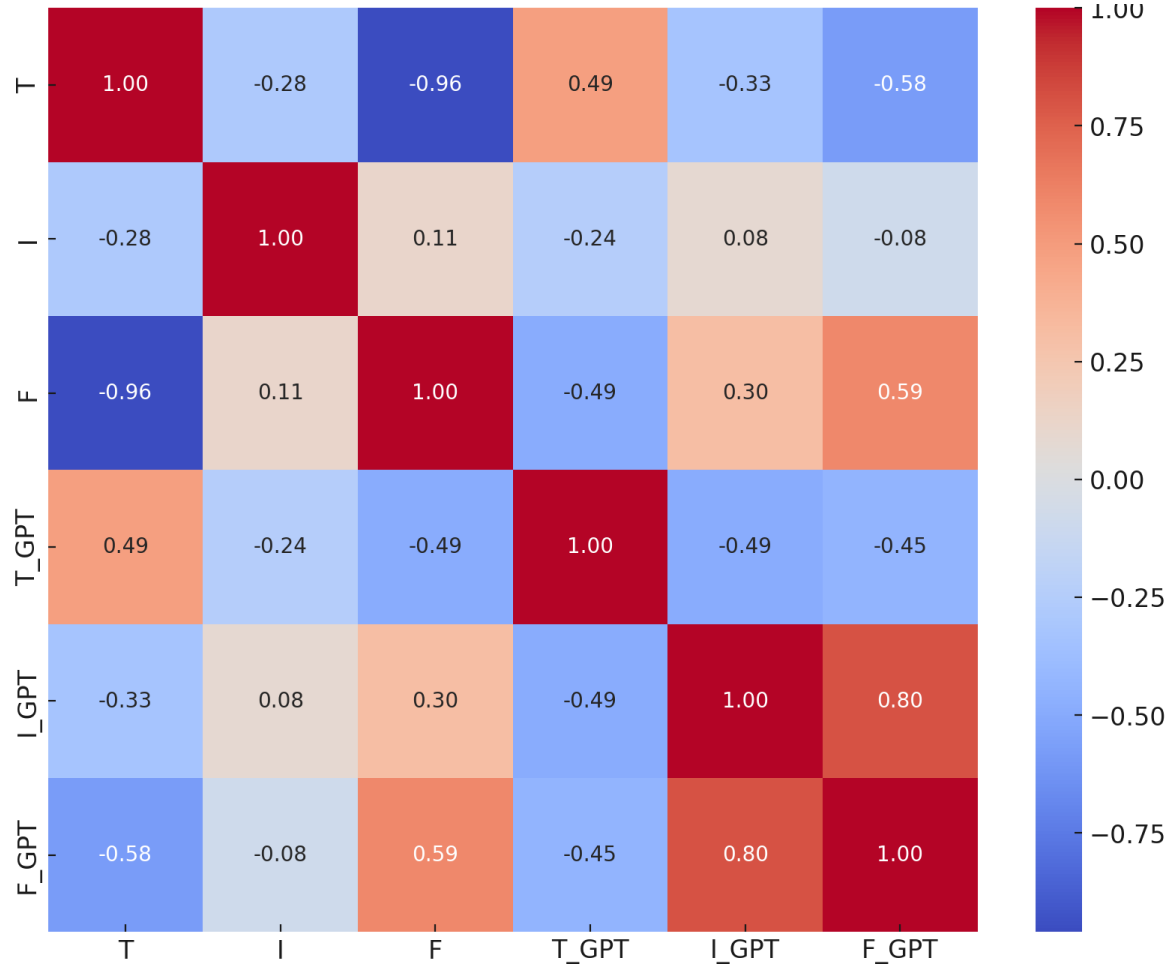

Figure 5. Correlation Between Original and GPT-Generated Variables

The Spearman correlation matrix reveals critical insights into the alignment between GPT-generated and human-assigned neutrosophic scores (Truth T, Indeterminacy I, Falsity F). Strong correlations dominate expected relationships, such as the near-perfect inverse link between real truth (T) and real falsehood (F) (ϱ = -0.96), confirming logical consistency in the original dataset.

However, GPT exhibits notable biases: a strong positive correlation between its indeterminacy (I_GPT) and falsehood (F_GPT) scores (ϱ = +0.80) suggests an artificial conflation of uncertainty and falsity, diverging from human interpretations. Moderate correlations, such as between real and GPT-generated falsehood (FFF vs. F_GPT, ϱ = +0.59) and partial alignment in truth (T vs. T_GPT, ϱ = +0.48), indicate limited fidelity in replicating nuanced judgments. Weak correlations, particularly between real and GPT indeterminacy (I vs. IGPT, ϱ = +0.08), highlight GPT's inability to interpret uncertainty in culturally contextualized frameworks.

The analysis underscores systemic gaps in GPT's capacity to emulate human-like reasoning within Andean philosophical contexts. The model's near-negligible correlation with indeterminacy values and its skewed association of falsehood with uncertainty reflect oversimplified probabilistic assumptions, potentially erasing culturally specific interpretations of ambiguity (e.g., Yanantin dualities). Additionally, the inverse relationship between real falsehood (F) and GPT truth (T_GPT, ϱ = -0.49) reveals partial adherence to logical truth-falsehood dichotomies but lacks full coherence. Coupled with low cosine similarity in textual justifications—indicating stylistic mismatches—these findings emphasize the need for domain-specific fine-tuning. Enhancing GPT's cultural fidelity may require training on annotated datasets that explicitly encode indeterminacy and contextual falsehood, alongside hybrid frameworks integrating expert validation to bridge epistemic gaps in Indigenous knowledge representation.

Semantic Similarity Analysis

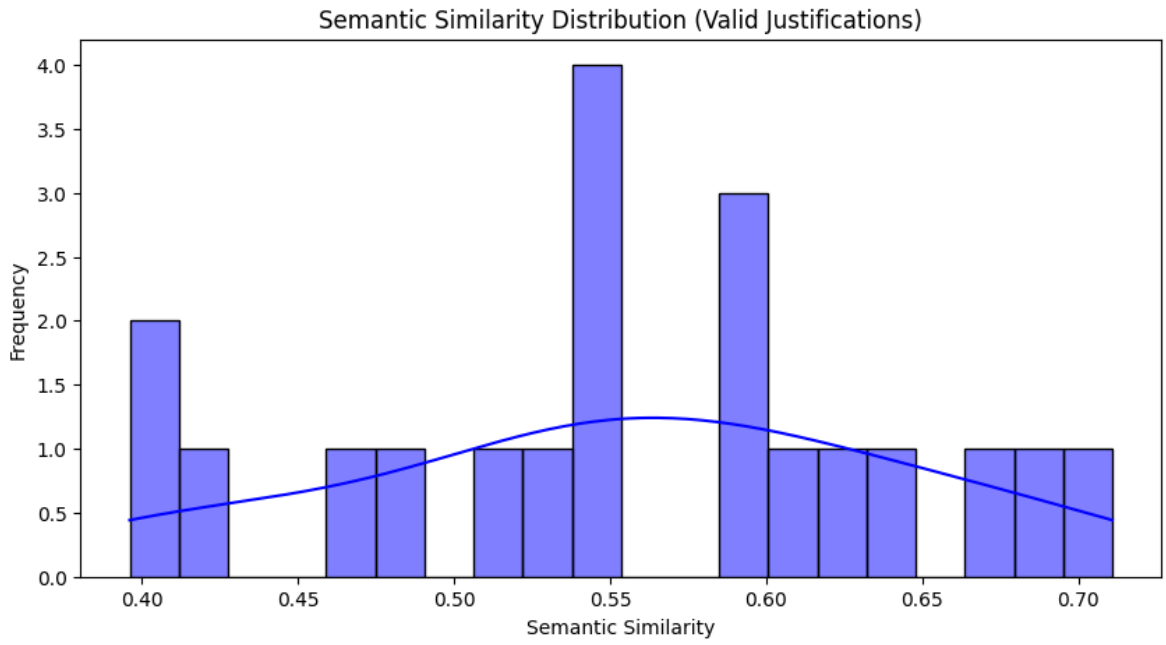

Figure 6. Distribution of Semantic Similarity

The semantic comparison via cosine similarity between GPT-generated and original justifications reveals moderate alignment, with an average similarity score of 0.5558 after filtering invalid responses (2 out of 22 removed). This intermediate value suggests that while GPT captures some aspects of the original justifications, there remain notable differences in expression and content depth when addressing Andean philosophical concepts. The distribution analysis demonstrates that GPT's outputs maintain a baseline level of semantic coherence, though with varying degrees of success in replicating the nuanced cultural content.

The semantic similarity scores span a range of 0.40 to 0.71, with a bimodal distribution showing peaks around 0.55 and 0.60, as evidenced in the histogram. The highest similarity score (0.71) was achieved in responses discussing the suma qamaña concept, indicating GPT's stronger performance when engaging with well-defined philosophical principles. The lower range (0.40-0.45) typically corresponds to cases where GPT defaulted to formulaic analytical frameworks (e.g., "Para poder asignar valores a la afirmación..."), rather than engaging directly with the cultural content. The clustering of scores in the 0.55-0.65 range suggests that GPT maintains consistent but moderate fidelity to the original justifications' semantic content.

The analysis reveals two key patterns: (1) GPT achieves higher similarity scores (0.65-0.71) when discussing specific cultural concepts or cited works, as seen in the top-performing justifications about suma qamaña and Silvia Rivera Cusicanqui's work, and (2) lower scores (0.40-0.48) correlate with responses that adopt a generic analytical framework rather than engaging with the specific cultural context. The bimodal distribution visible in the histogram suggests two distinct response patterns: one maintaining closer semantic alignment with cultural content (higher peak) and another falling back on more generic analytical structures (lower peak). These findings indicate that while GPT can engage meaningfully with Andean philosophical concepts, its performance varies significantly based on the specificity of the cultural content and its ability to avoid defaulting to generic analytical frameworks.

To enhance GPT-4's alignment with Andean philosophical concepts, targeted strategies are recommended: additional training with culturally specific examples to deepen contextual understanding, refined generation prompts emphasizing replication of the original dataset's style and content, and post-processing techniques like paraphrasing to improve semantic similarity. While GPT-4 demonstrates the potential for analyzing Andean epistemology, critical gaps persist, including inconsistent handling of indeterminacy, limited semantic fidelity in justifications, and biases in truth-value assignments. These limitations underscore the need for domain-specific fine-tuning, integration of cultural expertise, and hybrid validation frameworks to bridge algorithmic outputs with Indigenous knowledge systems. Future research should prioritize collaborative approaches with local scholars to ensure both technical and epistemic accuracy in cross-cultural computational analyses [30].

The study presents key limitations, such as the use of a small dataset (20 Andean philosophical statements), which restricts the generalization of findings, and the reliance on GPT-4. To address these aspects, the following improvements are recommended: (1) expand the dataset with more contextualized examples, including regional variations and ritual practices; (2) utilize more recent language models and refine prompts with Andean epistemological annotations; (3) integrate post-processing techniques (e.g., fine-tuning with Quechua/Spanish bilingual corpora) and implement [31] technical and cultural accuracy in representing uncertainty and complementary dualities.

5. Conclusions

This study has explored the profound interconnection between Andean epistemology and neutrosophic logic, demonstrating its potential to enrich science and artificial intelligence (AI). The ability of neutrosophy to encompass truth, falsehood, and indeterminacy makes it an exceptional tool for capturing the complexities of Andean thought, which transcends traditional binary logic by embracing the complementarity of opposites, interdependence, and coexistence. However, key limitations emerged in the use of GPT-4, including its biases toward overestimating truth values (T) and artificially clustering indeterminacy ($I \approx 0.7$), which oversimplify nuanced concepts such as yanantin (complementarity) and ch'ixi (simultaneous coexistence). Furthermore, the low average semantic similarity (cosine = 0.17) between AI-generated and original justifications highlights the

model's current limitations in replicating cultural nuances and domain-specific terminology, underscoring the need for culturally grounded AI frameworks.

Andean epistemology, with its emphasis on reciprocity and relationality, offers an invaluable perspective for designing ethical and responsible AI. Incorporating concepts such as Ayni (reciprocity) and Yanantin (complementarity) allows us to develop systems that consider not only individual data points but also the relationships and contexts in which they are generated, promoting social justice and sustainability. To advance this integration, future work should prioritize:

- Expanding the dataset with contextualized examples, including regional variations and ritual practices, to enhance cultural representativeness.
- Leveraging newer language models and refining prompts with Andean epistemological annotations to better align AI outputs with Indigenous ontologies.
- Integrating post-processing techniques, such as fine-tuning with Quechua/Spanish bilingual corpora, and implementing hybrid validation through collaboration with Andean worldview experts, ensuring both technical rigor and cultural fidelity in representing uncertainty and complementary dualities.

By addressing these challenges, AI systems can evolve to better reflect the richness of Andean cosmovision, fostering a more inclusive technological future where technology serves humanity and the planet holistically

.**References**

[1] Rescher, N. (1969). Many-valued logic. In Topics in Philosophical Logic (pp. 54-125). Dordrecht: Springer Netherlands. 3
[2] Tajsin, E. (2023). On Two-Valued and Multiple-Valued Logic and on Paradoxes of Verity. Dialogue and Universalism, (1), 143-161.
[3] Barad, K. Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning; Duke University Press: Durham, NC, USA, 2007. DOI: 10.1215/9780822388128.
[4] Escobar, A. Designs for the Pluriverse: Radical Interdependence, Autonomy, and the Making of Worlds; Duke University Press: Durham, NC, USA, 2018. DOI: 10.1215/9780822371816.
[5] Kohn, E. How Forests Think: Toward an Anthropology Beyond the Human; University of California Press: Berkeley, CA, USA, 2013. DOI: 10.1525/9780520956865.
[6] Rivera Cusicanqui, S. Ch'ixinakax Utxiwa: On Practices and Discourses of Decolonization; Polity Press: Cambridge, UK, 2020.
[7] Almeida, E., Cajas, D., & Amaru Chimba, J. (2021). Aspectos relevantes de la cosmovisión andina mediante narrativas para el fortalecimiento de la identidad y el orgullo cultural de las comunidades kichwa del norte del Ecuador. Revista Estudios del Desarrollo Social: Cuba y América Latina, 9(2).
[8] Huambachano, M. (2015). THE AYNI PRINCIPLE. Indigenous Spiritualities at Work: Transforming the Spirit of Enterprise, 99.
[9] Smarandache, F. (1999). A unifying field in Logics: Neutrosophic Logic. In Philosophy (pp. 1-141). American Research Press.
[10] Mignolo, W. The Darker Side of Western Modernity: Global Futures, Decolonial Options; Duke University Press: Durham, NC, USA, 2011. DOI: 10.1215/9780822394501.
[11] Priest, G. In Contradiction: A Study of the Transconsistent; Oxford University Press: Oxford, UK, 2006. DOI: 10.1093/acprof:oso /9780199263298.001.0001.
[12] de la Cadena, M. Earth Beings: Ecologies of Practice Across Andean Worlds; Duke University Press: Durham, NC, USA, 2015. DOI: 10.1215/9780822375265.

[13] Nail, T. Being and Motion; Oxford University Press: Oxford, UK, 2019. DOI: 10.1093/oso/9780190908904.001.0001.
[14] Vázquez, M. L., & Smarandache, F. (2024). A Neutrosophic Approach to Study Agnotology: A Case Study on Climate Change Beliefs. HyperSoft Set Methods in Engineering, 2, 1-8.
[15] Taylor, S. L. (2013). An investigation of the mechanical and physical properties of copper-silver alloys and the use of these alloys in Pre-Columbian America (Doctoral dissertation, Massachusetts Institute of Technology)
[16] Mandour, S. (2023). An Exhaustive Review of Neutrosophic Logic in Addressing Image Processing Issues. Neutrosophic Systems with Applications, 12, 36-55.
[17] Smarandache, F. (2010). Neutrosophic logic-a generalization of the intuitionistic fuzzy logic. Multispace & multistructure. Neutrosophic transdisciplinarity (100 collected papers of science), 4, 396.
[18] Webb, H. S. (2012). Yanantin and Masintin in the Andean world: Complementary dualism in modern Peru. UNM Press.
[19] Cruz Yasaca, G. A., Castro Guevara, J. E., Chariguamán Peñaloza, J. A., & Soxo Andachi, J. W. (2023). Escala lingüística neutrosófica para la autoevaluación del conocimiento sobre la justicia indígena en la modernidad del derecho occidental. Revista Científica, 28, 174–183. https://doi.org/10.5281/zenodo.8399632
[20] Smarandache, F. (2023). The MultiAlist System of Thought. Neutrosophic Sets and Systems, 61, 598-605.
[21] Vázquez, M. Y. L., & Smarandache, F. (2024). Integrating Contradictory Perspectives in Latin American Philosophy: A MultiAlism Approach. Infinite Study.
[22] García-Guano, A. J., Ruiz-Pinto, V. S., Paredes-Calderón, B. A., & López, M. E. L. (2024). Application of NCMs and MultiAlism in Indigenous Art Analysis. Neutrosophic Sets and Systems, 69, 1-10.
[23] Smarandache, F. (2024). Neutrosophy Transcends Binary Oppositions in Mythology and Folklore. Neutrosophic Sets and Systems, 65, 57-79.
[24] OpenAI, R. (2023). Gpt-4 technical report. arxiv 2303.08774. View in Article, 2(5).
[25] Spearman, C. (1904). The proof and measurement of association between two things. The American Journal of Psychology, 15(1), 72–101. https://doi.org/10.2307/1412159
[26] Tatachar, A. V. (2021). Comparative assessment of regression models based on model evaluation metrics. International Journal of Innovative Technology and Exploring Engineering, 8(9), 853-860.
[27] Abdulhafedh, A. (2021). Incorporating k-means, hierarchical clustering and pca in customer segmentation. Journal of City and Development, 3(1), 12-30.
[28] Reimers, N., & Gurevych, I. (2019). Sentence-BERT: Sentence Embeddings using Siamese BERT-Networks. Proceedings of the 2019 Conference on Empirical Methods in Natural Language Processing. http://arxiv.org/abs/1908.10084
[29] Jurafsky, D., & Martin, J. H. (2020). Speech and Language Processing (3rd ed.). Pearson. https://web.stanford.edu/~jurafsky/slp3/
[30] Lewis, J. E., Yolgörmez, C., & Whaanga, H. (2024). Abundant intelligences: Placing AI within Indigenous knowledge frameworks. AI & Society. https://doi.org/10.1007/s00146-024-02099-4
[31] Concordia University. (2024, January 22). Concordia launches innovative research program to indigenize artificial intelligence. Scienmag. https://scienmag.com/concordia-launches-innovative-research-program-to-indigenize-artificial-intelligence/

Received: Oct 23, 2024. Accepted: Feb 4, 2025