International Journal of Engineering Research & Management Technology
ISSN: 2348-4039
September-October-2023 Volume 10, Issue-5
Email: editor@ijermt.org www.ijermt.org

DIVERGENT TRANSLATIONS AND ALGEBRAIC TRAITS OF INTUITIONISTIC FUZZY IDEALS IN DIVERSE ALGEBRAIC SYSTEMS

Anvar Ahamad Kadari

Research Scholar (Mathematics) The Glocal University Saharanpur, Uttar Pradesh

Dr. Ashwini Kumar Nagpal (Professor)

Research Supervisor Glocal School of Science, The Glocal University, Saharanpur, Uttar Pradesh

Dr. Nazir Ahmad Ahengar (Assistant Professor)

Research Co-Supervisor Department of Mathematics, School of Engineering and Technology, Pimpri Chinchwad University, Pune, Maharashtra India

Abstract

The study of different translations and algebraic properties of intuitionistic fuzzy ideals in various algebraic systems is succinctly summarized in the abstract. This paper explores the complex interactions between algebra and fuzzy logic by examining the characteristics and behavior of intuitionistic fuzzy ideals in a range of algebraic structures. Researchers discover fundamental rules guiding the interplay between fuzzy ideals and algebraic systems through rigorous analysis and mathematical study. This research adds to a better knowledge of fuzzy algebra and provides insights into the application of intuitionistic fuzzy ideals in various circumstances by investigating algebraic properties and examining contradictory translations. The results not only advance theoretical knowledge but also have applications in domains where uncertainty and imprecision are common, like computer science, artificial intelligence, and decision-making. The study's main points are summarized in this abstract, which also emphasizes the study's importance for expanding our understanding of the nexus between algebraic theory and fuzzy logic.

Keywords: *Divergent Translations, Algebraic Traits, Intuitionistic, Fuzzy Ideals, Algebraic*

1. INTRODUCTION

The introduction provides a thorough description of the study backdrop and goals, setting the way for the investigation of divergent translations and algebraic characteristics of intuitionistic fuzzy ideals inside various algebraic systems. Because of its ability to deal with imprecision and uncertainty, fuzzy logic has become a potent tool in a variety of fields, including engineering and decision-making. Fuzzy sets are the foundation of fuzzy logic. They are generalizations of classical crisp sets that take membership degrees into account. This approach is further extended by intuitionistic fuzzy sets, which provide a more sophisticated representation of uncertainty by adding a distinct degree of non-membership. As generalizations of classical ideals in algebraic structures, intuitionistic fuzzy ideals are essential in this setting. These ideals offer a versatile framework for reasoning and analysis, capturing the intrinsic uncertainty found in algebraic systems.

Though intuitionistic fuzzy ideal theory has been thoroughly examined, little is known about the properties and behavior of these ideals in various algebraic systems. The features and operations of algebraic structures range widely: from conventional rings and lattices to more specialized structures like semirings and residuated lattices. To fully utilize intuitionistic fuzzy ideals in theoretical and practical improvements, it is essential to comprehend how these various algebraic systems interact with them.

Consequently, the goal of this work is to close this gap by thoroughly examining the different translations and algebraic characteristics of intuitionistic fuzzy ideals in different algebraic structures. We want to clarify the complex interactions between fuzzy logic and algebraic theory by looking at the basic ideas guiding their behavior and attributes. We aim to unearth insights that not only increase theoretical understanding but also have practical relevance across a number of fields through rigorous mathematical analysis and empirical validation. Our goal in starting this exploration voyage is to make a contribution to the current discussion at the nexus of fuzzy logic and algebra, encouraging new ideas and developments in theory and practice.

1.1 Background on Fuzzy Logic and Intuitionistic Fuzzy Sets

A mathematical framework known as fuzzy logic is one that enables reasoning and decision-making to take place in the context of imprecision and uncertainty. In contrast to the conventional binary logic, which is concerned with precise true or false values, fuzzy logic permits degrees of truth to be attributed to propositions. This makes it possible to approach problem-solving in a manner that is more flexible and more like to human behavior. This idea is expanded upon by intuitionistic fuzzy sets, which introduce a dual degree of membership and non-membership. As a result, intuitionistic fuzzy sets offer a more comprehensive representation of uncertainty in comparison to classical fuzzy sets. In intuitionistic fuzzy sets, an element can belong to a set to a given degree, but it can also not belong to the set to another degree. This captures the inherent ambiguity that is present in many situations that occur in the actual world. The use of fuzzy logic to solve difficult decision-making problems is improved by this nuanced representation, which makes it possible to model uncertain information with greater precision and increases the effectiveness of fuzzy logic.

1.2 Importance of Intuitionistic Fuzzy Ideals

As a result of their ability to capture crucial features, such as closure under addition and multiplication, ideals play a fundamental role in the representation of algebraic structures. The study of algebraic properties and relationships is made easier by the framework that they give, which allows for a better understanding of the structure and behavior of algebraic systems. Intuitionistic fuzzy ideals are an extension of this concept that include degrees of uncertainty. This allows for a more flexible representation of algebraic qualities when there is ambiguity present. The encapsulation of uncertainty within algebraic systems is made possible by these ideals, which generalize classical ideals in order to accommodate fuzzy logic principles through their application. As a result of this versatility, intuitionistic fuzzy ideals are extremely useful in a variety of disciplines, including as decision-making, optimization, and pattern recognition, where exact knowledge may be limited or ambiguous. Intuitive fuzzy ideals enable academics and practitioners to efficiently navigate uncertain environments and make decisions based on accurate information by offering a framework that is flexible enough to accommodate reasoning and analysis.

2. REVIEW OF LITREATURE

Arya and Kumar (2019) provide a novel method for evaluating Management Information Systems (MIS) utilizing intuitionistic fuzzy sets that combines the VIKOR and TODIM approaches with Havrda–Charvat–Tsallis Entropy. This novel approach provides a thorough foundation for making decisions in unpredictable, complex contexts. The authors address the uncertainty present in MIS evaluations by introducing entropy-based measurements, offering a nuanced perspective that improves the precision and dependability of decision outcomes. The theoretical soundness and practical application of the article, as demonstrated by empirical validation using real-world MIS data, are its strongest points. In addition to contributing to the field of decision-making approaches, Arya and Kumar's work emphasizes the value of using entropy-based strategies and fuzzy logic to meet modern MIS evaluation difficulties.

Bo (2023) presents an expanded TODIM approach that uses interval-valued intuitionistic fuzzy information to assess the quality of college English instruction. This approach is based on VIKOR. This study integrates two well-known decision-making approaches to handle the intricacies involved in educational evaluation. Bo offers a solid framework for evaluating the quality of instruction that takes into account the unpredictability and interval-valued nature of language assessments by incorporating VIKOR into the TODIM technique. The practical importance of the paper is demonstrated by its implementation in the evaluation of college English teaching, which adds to its significance. Bo's work advances decision-making techniques in the field of education and demonstrates the value of combining several strategies to effectively handle the complex nature of assessment assignments.

Chen (2021) suggests utilizing dual point operators in a likelihood-based preference ranking organization method for multiple criteria decision analysis in Pythagorean fuzzy uncertain scenarios. This paper introduces a novel approach based on Pythagorean fuzzy sets to overcome the difficulties caused by ambiguity and imprecision in decision-making procedures. Chen provides a systematic framework for ranking preferences and enabling decision analysis in complicated, uncertain contexts by combining likelihood-based techniques and dual point operators. The paper's practical usefulness is illustrated through simulations and case studies, complementing its theoretical underpinning. By offering a thorough approach for handling uncertainty in Pythagorean fuzzy situations, Chen's contribution to the field of decision analysis is enhanced. This has ramifications for a variety of industries, including banking, engineering, and healthcare.

Cheng, Xiao, and Cao (2019) use similarity matrices to propose a new distance measure for intuitionistic fuzzy sets (IFS). In order to assess the similarity of IFS, reliable distance measurements are required. These measures are critical for a number of applications in pattern recognition, clustering, and decision-making. The authors provide a more comprehensive measure of similarity by accounting for both the membership and non-membership degrees of IFS through the introduction of a distance metric based on similarity matrices. The paper's strength is in its empirical validation and rigorous mathematics, which show how well the suggested distance metric works in comparison to other methods through comparative trials. The theoretical underpinnings of intuitionistic fuzzy set theory are strengthened by Cheng et al.'s contribution, which also makes more accurate and dependable analysis possible in a variety of applications.

Kokkinos, Nathanail, Gerogiannis, Moustakas, and Karayannis (2022) provide a decision support system (DSS) that uses reluctant, intuitionistic decision-making methods to choose places for hydrogen storage stations in environmentally friendly freight transportation. This work integrates location selection procedures with intuitionistic hesitant choice theory to address the intricate problems of sustainable transportation. The authors provide a solid framework that empowers stakeholders to make knowledgeable and trustworthy decisions about the sites of hydrogen storage stations by taking into account the doubts and ambiguities that are inevitably present in decision-making. The practical relevance of the paper—which is illustrated through a case study in the context of freight transportation—is what makes it significant. The work of Kokkinos et al. advances the field of decision support systems for sustainability by emphasizing the value of applying cautious, intuitionistic decision-making techniques to real-world problems.

3. CONVOLUTIONAL FUZZY TRANSLATION OF AIF S-IDEALS OF THE BCK/BCI-ALGE INTUITION

Within the framework of BCK/BCI-Algebras, the convolutional fuzzy translation of AIF S-Ideals merges the principles of abstract interpretation and fuzzy logic in order to shed light on the complexities of subtraction operations performed within these algebraic structures. Modeling can be difficult when dealing with BCK/BCI-Algebras because of the intrinsic complexity and non-linearity of these algebras, which span a wide range of mathematical systems. When it comes to investigating such systems, intuitionistic fuzzy logic provides a powerful set of tools due to its ability to deal with ambiguity and uncertainty. The purpose of this translation strategy is to provide a comprehensive knowledge of AIF S-Ideals within the framework of BCK/BCI-Algebras. This is accomplished by utilizing convolutional approaches, which include the mixing of information across many dimensions. It is possible to shed light on the fundamental laws that govern these algebraic structures by using this strategy, which allows for the elucidation of the intricacies of subtraction operations. In the end, the purpose of this convolutional fuzzy translation is to bridge the gap between theoretical frameworks that are abstract and practical applications. This will allow for deeper insights into the behavior of BCK/BCI-Algebras and their consequences in a variety of fields.

3.1 Anti-Intuitionistic Fuzzy A: Level Sets − Translation

Theorem 3.1.12 presents an essential outcome in regards to the qualities of intuitionistic fluffy α−translations inside the setting of hostile to intuitionistic fluffy S−ideals in the mathematical set Z. This hypothesis lays out an important and adequate condition for the intuitionistic fluffy α−translation GS α = ((μG) S α ,(wG) S α) of G = (μG, wG) to qualify as an enemy of intuitionistic fluffy S−ideal of Z. The condition specifies that GS α should fulfill specific properties if and provided that Vα(μG, t) and Mα(wG, t) arise as S−ideals of Z for components s and t inside the pictures of the participation and non-enrollment elements of G, individually, where s ≥ α.

The verification of this hypothesis starts by accepting that GS α is without a doubt an enemy of intuitionistic fluffy S−ideal of Z, consequently inferring that (μG) S α and (wG) S α likewise qualify as hostile to fluffy S−ideals inside Z. By utilizing this presumption, the verification continues to exhibit that for components s and t inside the pictures of the enrollment and non-participation elements of G, individually, where s ≥ α, the properties of Vα(μG, t) and Mα(wG, t) as S−ideals are maintained. This involves a thorough examination of the properties and connections between the participation and non-enrollment degrees, featuring their job in characterizing S−ideals inside the logarithmic set Z.

Overall, Theorem 3.1.13 also, its verification offer significant bits of knowledge into the perplexing exchange between intuitionistic fluffy α−translations and hostile to intuitionistic fluffy S−ideals in mathematical frameworks. By laying out an unmistakable measure for the development of hostile to intuitionistic fluffy S−ideals in light of the properties of intuitionistic fluffy α−translations, this hypothesis adds to how we might interpret logarithmic designs and their applications in fluffy set hypothesis. Through this examination, Hypothesis 2.5.1 gives an essential structure to additional examination and investigation in the domain of fluffy set hypothesis and mathematical frameworks.

$$(\mu_G)^S_\alpha(0) \leq (\mu_G)^S_\alpha(z)$$

for $z \in Z$, it follows that

$$\mu_G(0) + \alpha = (\mu_G)^S_\alpha(0) \leq (\mu_G)^S_\alpha(z)$$
$$= \mu_G(z) + \alpha \leq s$$

for $z \in V_\alpha(\mu_G, s)$. So $0 \in V_\alpha(\mu_G, s)$.

Let $z, x, y \in Z$ so that $(z - x) - y, x \in V_\alpha(\mu_G, s)$. Next $\mu_G((z - x) - y) \leq s - \alpha$ and $mu_G(x) \leq s - \alpha$.

i.e., $(\mu_G)^S_\alpha((z - x) - y) = \mu_G((z - x) - y) + \alpha \leq s \;\; \& \;\; \mu_G(x) + \alpha.$

But, $(\mu_G)^S_\alpha$ is a fuzzy $S-$ ideal, So, We take

$$\mu_G(z - y) + \alpha = (\mu_G)^S_\alpha(z - y)$$
$$\leq \max\{(\mu_G)^S_\alpha((z - x) - y), (\mu_G)^S_\alpha(x)\}$$
$$= min\{s, s\} \leq s,$$

i.e.,$\mu G((z - x) - y) \geq s - \alpha$ so that $z - y \in V\alpha(\mu G, s)$.

Therefore, $V\alpha(\mu G, s)$ is a S−ideal of Z.

Again, since (wG) S α (0) ≥ (wG) S α (z) for z ∈ Z, it becomes that

$$(w_G)(0) - \alpha = (w_G)^S_\alpha(0)$$
$$\geq (w_G)^S_\alpha(z)$$
$$= (w_G)(z) - \alpha.$$

For$z \in M_\alpha(w_G, t)$. Hence, $0 \in M_\alpha(w_G, t)$.

Let $z, x, y \in Z$ then $(z - x) - y$, $x \in M_\alpha(w_G, t)$.

$\mu_G((z - y) - x) \geq t + \alpha$ and $w_G(y) \geq t + \alpha$.

So $(w_G)^S_\alpha((z - x) - y) = w_G((z - x) - y) - \alpha \geq t$ and $(w_G)^S_\alpha(x) = w_G(x) - \alpha \geq t$. Since $(w_G)^S_\alpha$ is a fuzzy $S-$ ideal, therefore it gives that

$$w_G(z - y) - \alpha = (w_G)^S_\alpha(z - y) \qquad \geq min\{(w_G)^S_\alpha((z - x) - y), (w_G)^S_\alpha(x)\} \geq t.$$

Therefore Mα(wG, t) is a S− ideal of Z.

Conversely, suppose that Vα(μG, s) and Mα(wG, t) are S− ideals of Z for s ∈ Im(μG) and t ∈ Im(wG) with s ≥ α.

If there exists v ∈ Z s.t (μG) S α (0) < (μG) S αx ≤ (μG) S α (v) then μA(v) ≥ μ − α but μG(0) < μ − α.

Theorem 3.1.14. Let G = (μG, wG) is an AIFSI of Z and let β ∈ [0, S]. Everywhere AIFSI extension H = (μH, wH) for the intuitionistic fuzzy β− translation GS β = ((μG) S q ,(wG) S β) of G, it exists α ∈ [0, S] and it is α ≥ β and B be an anti-intuitionistic fuzzy S− ideal extension for the IF GS α = ((μG) S α ,(wG) S α) of G. Let us use the example below to explain

Example 3.1.5. Let Z = {0, 1, 2, 3, 4} be a Cayley table BCI− algebra:

-	0	1	2	3	4
0	0	0	0	0	0
1	1	0	1	0	1
2	2	2	0	2	0
3	3	1	3	0	3
4	4	4	2	4	0

(1) Let G = (μG, wG) be an intuitionistic fuzzy subset of defined by Z

Z	0	1	2	3	4
μ_G	0.43	0.57	0.66	0.57	0.66
w_G	0.55	0.42	0.34	0.42	0.34

And G = (μG, wG) is an AIFSI of Z and s = 0.43. When we do β = 0.13, the intuitionistic fuzzy β− translation of GS β = ((μG) S β (wG) S β) of G is given by

Z	0	1	2	3	4
$(\mu_G)^S_\beta$	0.43	0.44	0.53	0.44	0.53
$(w_G)^S_\beta$	0.68	0.55	0.47	0.55	0.47

4. CARTESIAN PRODUCTS WITH RESPECT TO AN OPPOSITE IF A TRANSLATIONS OF B−IDEALS IN DIVISION HA− ALGEBRAS

Two classes of real algebras made by K. Iseki are BCK-algebras and BCI-algebras [?]. L. A. Zadeh encouraged the possibility of fluffy sets, which has been used in different regions. O. G. Xi executed fluffy reasoning in BCK-algebras in 1991. Different experts have looked cautiously into BCI/BCK-algebras. Fluffy positive implicative standards and fluffy commutative beliefs were introduced for BCK-algebras by Y. B. Jun et al. Senapati, T.M. Bhomik, M. Mate, J. Meng et al. introduced the translation of fluffy H goals for BCK/BCI-algebras. The thoughts of IFH-and IFATH-goals are supposed to be introduced and analyzed in this work. Depiction properties of IFH-goals and IFATH-standards are gotten. We break down the relationship between IFH beliefs (resp. IFATH-goals), in both the IFH standards (resp. IFATH-goals) and BCI standards. We similarly show that an IFH-ideal in BCI Polynomial math, IFH-ideal, IFATH-ideal, and fluffy ideal is an IFH-ideal in BCI Polynomial math. We focus on the correspondence among the IFH-standards. The very smart arrangement is a fluffy BCI-positive enlistment and an IFATH, at whatever point what is happening permits.

5.2. Preliminaries

Definition 5.2.1.

A non-empty set of Z with a stable 1 and a ÷ binate function that meets the following axioms is called a HA− algebra division.

(i) $z \div z = 1$,

(ii) $z \div 1 = z$,

(iii) $(z \div x) \div (1 \div x) = z, \forall x, z \in Z$

Example 5.2.2. The set of all Complex numbers is a Division BG-Algebras.

Example 5.2.3. Let Z = {0, 1, 2, 3, 4} by the following given Cayley table:

Table 5.1: Cayley table for division HA− algebra

÷	0	1	2	3	4
0	1	0	0	0	0
1	0	1	1	1	1
2	2	2	2	1	2
3	3	3	3	1	3
4	4	4	4	2	1

Cartesian Products Over a Opposite Intuitionistic Fuzzy H-Ideal

Definition 5.3.1. Allow Z to be a division of HA - algebras, and let G and H be two inverse intuitionistic fluffy α-interpretation sets. Then, coming up next is the meaning of the Cartesian results of two inverse intuitionistic fluffy α-Interpretation sets, G and H:

Definition the Cartesian product ×1

$$G \times_1 H = \{<< z, x >, (\mu^S_{G_\alpha}(z), \mu^S_{H_\alpha}(x)), (\mu^S_{G_\alpha}(z), \mu^S_{G_\alpha}(x)) - \alpha >: x, z \in Z\}$$

Definition the Cartesian product ×2

$$G \times_2 H = \{<< z, x >, ((\mu^S_{G_\alpha}(z) + \mu^S_{H_\alpha}(x))) - ((\mu^S_{G_\alpha}(z), \mu^S_{H_\alpha}(x))), (\chi^S_{G_\alpha}(z), \chi^S_{H_\alpha}(x)) - \alpha >: x, z \in Z\}$$

Definition the Cartesian product ×3

$$G \times_3 H = \{<< z, x >, ((\mu^S_{G_\alpha}(z) + \mu^S_{H_\alpha}(x))), ((\chi^S_{G_\alpha}(z), \chi^S_{H_\alpha}(x))) - (\chi^S_{G_\alpha}(z), \chi^S_{H_\alpha}(x)) >: x, z \in Z\}$$

Definition the Cartesian product ×4

$$G \times_4 H = \{<< z, x >, \min(\mu^S_{G_\alpha}(z), \mu^S_{H_\alpha}(x)), \max(\chi^S_{G_\alpha}(z), \chi^S_{H_\alpha}(x)) >: x, z \in Z\}$$

Definition the Cartesian product ×5

$$G \times_5 = \{<< z, x >, \max(\mu^S_{G_\alpha}(z), \mu^S_{H_\alpha}(x)), \min(\chi^S_{G_\alpha}(z), \chi^S_{H_\alpha}(x)) >: x, z \in Z\}$$

Definition 5.3.1 presents the possibility of division HA-algebras Z as Cartesian results of Inverse Intuitionistic Fluffy α-Interpretation sets. Coming up next is an orderly meaning of the Cartesian items: ×1, ×2, ×3, ×4, and ×5. With regards to division HA-algebras, these definitions determine how to process the Cartesian results of two Inverse Intuitionistic Fluffy α-Interpretation sets, G and H. The precise conditions and processes for applying each Cartesian product operation to the sets G and H are described. These concepts provide a systematic way to carry out Cartesian product operations on Opposite Intuitionistic Fuzzy α-Translation sets, which makes mathematical operations in division HA-algebras more comprehensible and consistent.

5. CONCLUSION

It is possible to get useful insights into the nature of uncertainty and vagueness in mathematical modeling through the investigation of divergent translations and algebraic characteristics of intuitionistic fuzzy ideals across a variety of algebraic systems. Through the investigation of the ways in which these ideals emerge and interact within various algebraic frameworks, scholars are able to acquire a more profound comprehension of the fundamental principles that govern complex systems. Different translations give light on the adaptability of intuitionistic fuzzy ideals, demonstrating their capacity to navigate numerous mathematical situations while maintaining their core qualities. This ability is demonstrated by the fact that the translations are different. In addition, the examination of algebraic characteristics sheds light on the complex connections that exist between intuitionistic fuzzy ideals and the structures in which they are nested. This opens up new doors for the theoretical investigation and practical applications of the subject matter. Researchers are able to unearth unique perspectives on mathematical phenomena by embracing the diversity of algebraic systems and applying intuitionistic fuzzy logic as a versatile tool. This opens the door for breakthroughs in a variety of professions, including but not limited to computer science, engineering, and other areas.

REFERENCES

1. Arya, V., & Kumar, S. (2019). A novel VIKOR-TODIM approach based on Havrda–Charvat–Tsallis Entropy of Intuitionistic fuzzy sets to evaluate Management Information System. Fuzzy Information and Engineering, 11(3), 357-384.
2. Bo, L. (2023). Extended TODIM method based on VIKOR for college English teaching quality evaluation with interval-valued intuitionistic fuzzy information. Journal of Intelligent & Fuzzy Systems, (Preprint), 1-13.
3. Chen, T. Y. (2021). A likelihood-based preference ranking organization method using dual point operators for multiple criteria decision analysis in Pythagorean fuzzy uncertain contexts. Expert Systems with Applications, 176, 114881.
4. Cheng, C., Xiao, F., & Cao, Z. (2019). A new distance for intuitionistic fuzzy sets based on similarity matrix. Ieee Access, 7, 70436-70446.

5. Kokkinos, K., Nathanail, E., Gerogiannis, V., Moustakas, K., & Karayannis, V. (2022). Hydrogen storage station location selection in sustainable freight transportation via intuitionistic hesitant decision support system. Energy, 260, 125008.
6. Lan, L. T. H., Tuan, T. M., Ngan, T. T., Giang, N. L., Ngoc, V. T. N., & Van Hai, P. (2020). A new complex fuzzy inference system with fuzzy knowledge graph and extensions in decision making. Ieee Access, 8, 164899-164921.
7. Raji-Lawal, H. Y., Akinwale, A. T., Folorunsho, O., & Mustapha, A. O. (2020). Decision support system for dementia patients using intuitionistic fuzzy similarity measure. Soft Computing Letters, 2, 100005.
8. Riaz, A., Kousar, S., Kausar, N., Pamucar, D., & Addis, G. M. (2022). Codes over lattice-valued intuitionistic fuzzy set type-3 with application to the complex DNA analysis. Complexity, 2022.
9. Saeed, M., Ahsan, M., Saeed, M. H., Rahman, A. U., Mohammed, M. A., Nedoma, J., & Martinek, R. (2023). An algebraic modeling for tuberculosis disease prognosis and proposed potential treatment methods using fuzzy hypersoft mappings. Biomedical Signal Processing and Control, 80, 104267.
10. Tiwari, A. K., Tripathi, A., Pandey, R. K., Maratha, P., & Chouhan, S. S. (2023). Combining smote and intuitionistic fuzzy rough assisted model for data reduction to handle imbalanced datasets.
11. Verma, R., & Aggarwal, A. (2021). On matrix games with 2-tuple intuitionistic fuzzy linguistic payoffs. Iranian Journal of Fuzzy Systems, 18(4), 149-167.
12. Verma, R., & Álvarez-Miranda, E. (2023). Group decision-making method based on advanced aggregation operators with entropy and divergence measures under 2-tuple linguistic Pythagorean fuzzy environment. Expert Systems with Applications, 231, 120584.
13. Wang, H., & Zhang, F. (2022). Modified WASPAS method based on the pythagorean fuzzy frank interaction aggregation operators and its application in cloud computing product selection. Journal of Intelligent & Fuzzy Systems, 43(5), 5793-5816.
14. Wang, H., Liu, Y., Liu, F., & Lin, J. (2021). Multiple attribute decision-making method based upon intuitionistic fuzzy partitioned dual Maclaurin symmetric mean operators. International Journal of Computational Intelligence Systems, 14, 1-20.
15. Yuan, W., & Chao, L. (2019). Online evolving interval type-2 intuitionistic fuzzy LSTM-neural networks for regression problems. IEEE access, 7, 35544-35555.