Neutrosophic Systems with Applications, Vol. 23, 2024
https://doi.org/10.61356/j.nswa.2024.23377

Product Perspective from Fuzzy to Neutrosophic Graph Extension- A Review of Literature

G. Vetrivel [1], M. Mullai [1,2]* and G. Rajchakit [3]

[1] Department of Mathematics, Alagappa University, Karaikudi, Tamilnadu, India.
Emails: menakagovindan@gmail.com; mullaim@alagappauniversity.ac.in
[2] Research Fellow, INTI International University, Nilai Campus, Malaysia;
[3] Department of Mathematics, Faculty of Science, Maejo University, Chiang Mai 50290, Thailand; kreangkri@mju.ac.th.

* Correspondence: mullaim@alagappauniversity.ac.in.

Abstract: This review article consolidates and tabulates research on the product operations done in fuzzy, intuitionistic fuzzy, and neutrosophic graphs. This article encompasses the previous product discussions on fuzzy graphs and their extensions. This article aims to list the origin, structural properties, applications, etc. done by the researchers and academicians using the product behavior of two graphs on the fuzzified environment. This review provides a clear understanding of enhancements of product approach on graphs from fuzzy to neutrosophic kind.

Keywords: Fuzzy Graph; Intuitionistic Fuzzy Graph; Neutrosophic Graph; Product.

1. Introduction

Graph theory is an essential area through which many real-world scenarios are analyzed and structured independently. It is widely applied in engineering, decision-making, chemical, and medical diagnosis. Euler (1736) solved the famous Konigsberg bridge problem, the foundation base for the graph theoretical approach. The structural components of a graph – vertex and edge play an important applicable part in social networking and data interpretation. However, the classical graph types fail to employ precise information in some systems comprised of complex features. There is a need to improvise the graph structure to make it extensible from the application point of view. This paves the way for the evolution of fuzzy sets and its extension. Numerous graphical phenomena and characteristics have been analyzed and established with the fuzzy and its extensible structures.

The crisp graph theory is a binary relationship that deals with specific values 0 and 1 to label the vertices and edges of the graph. The shortcomings of crisp graph theory give rise to the entry of fuzzy graphs and their models. A fuzzy graphical environment allows one to deal with uncertainty cases, which is valuable for real-life scenarios. Zadeh (1965) sowed the seed "fuzzy set", which acts as a base for the evolution of a fuzzy graph that breaks the restriction and proceeds with ambiguous information. Kaufmann (1973) developed a fuzzy graph definition, leading to the evolution of Rosenfeld's fuzzy graph model. Nagoorgani et al. empowered the fuzzy graph foundation through their innovative results and findings related to the structural representation of fuzzy graphs. Later, Atanassov (1986) coined a new set theory, "Intuitionistic Fuzzy Set (Int-FS)" which adds membership grade to the existing fuzzy set. Parvathi and Karunambigai (2009) renewed the existing graphical concept by inserting intuitionistic behavioral properties and membership grades. Akram (2016) and Nagoorgani (2010) studied the background of intuitionistic fuzzy works and conducted numerous explorations. Smarandache (1999) was the first to extend the total sum limit of memberships and launched one more membership grade to the existing intuitionistic graphical environment. Smarandache (2006, 2019) and Broumi (2016, 2018) inaugurated the neutrosophic set generalization and the graphical system with neutrosophic memberships. Furthermore, neutrosophic approaches to graph theory have a refined structure that enhances productivity and applicability in the present world scenario.

Various product operations are established in the fuzzy graphical environment and its extension. This product idea combines and consolidates the structure and features of two graphs and gives an enhanced output as a single graph obtained through various product operations. This kind of approach is most suitable for socioeconomic issues, brain network analysis, decision-making, etc. This article encloses the overall work on various product key operations of numerous kinds of fuzzy graphs to neutrosophic graphs. The paper is structured as follows: Section 1 covers the introductory part of the evolution of the graph theory from fuzzy to neutrosophic background. Sections 2, 3 & 4 enlist the various enrichments of product perspective in fuzzy, intuitionistic fuzzy, and neutrosophic graph theory respectively. The conclusion part is given in Section 5.

2. Different Product Discussions on Fuzzy Graphs

The enhancements related to the graph product methodology of the fuzzy environment are listed in Table 1.

Table 1. Several types of products in a fuzzy graphical environment.

Reference	Year	Graph Type	Findings/Approaches
[1]	1994	Fuzzy Graphs (FGs)	Operations like cartesian product, union, and join on fuzzy subgraphs are carried out with some theorems and examples.
[2]	2008		The conjunction of FGs is defined with some properties.
[3]	2014		Introduction of Beta and Gamma products of FGs and work on regular FGs is done.
[4]	2014		A strong product of fuzzy, effective fuzzy, and complete FG has been done. In addition, truncations and the degree of a vertex of the strong product of FGs are investigated.
[5]	2015		The maximal product of fuzzy, effective fuzzy, and connected FG is done. Also, the degree of a vertex and regularity is checked in the case of the maximal product of FGs.
[6]	2015		Listed out various types of products of FG, but a detailed discussion is done with modular, homomorphic, box dot, star product and their vertex degree of FGs.
[7]	2015		The residue product of two fuzzy graphs is structured. Some properties like effective, connected, and complete properties are studied on the residue product of two FGs. Also, the degree, total degree, and regularity of FG are illustrated.
[8]	2019		Maximal product is considered and intense notions are explained with properties and examples. Also, an application to identify controversial issues among countries is portrayed.

Mordeson [1] has a new idea for implementing some product operations in fuzzy graphs. The cartesian product was defined first, followed by theorems based on the cartesian product and fuzzy subgraphs. Likewise, composition, union, and join operations have been done and their operations and conditions on fuzzy subgraphs are widely discussed in the respective article with examples.

Nagoor Gani & Radha [2] introduced the operation name "conjunction" between two FGs. They came up with a necessary and sufficient condition for this conjunction to be strong. Also, the degree of vertices for this operation is found, and some theorems are dealt with. The degree-based regular property and adjacency sequence of conjunction are discussed further.

Nagoor Gani & Fathima Kani [3] coined the beta and gamma product of FGs. The degree of vertices and regularity property is applied for these products for specific cases and a necessary and sufficient condition for these product graphs to be regular is derived.

Radha & Arumugam [4] operated strong products in FGs for the first time. This product has been checked for effective, complete, and connected properties. In addition, the upper and lower truncations of this product are generated. The degree of a vertex of this product and its relation with the direct sum is acquired.

Shovan Dogra [5] has taken different products such as modular, homomorphic, box dot, and star graph products, and implemented them in FGs. Also, these products are executed with strong FGs. Finally, the degree of the vertex for all these products is found.

Radha & Arumugam [6] initiated the product "maximal product" and incurred in FGs to prove its effective and connected properties. The vertex degree of the maximal product and its regularity are discussed with some restrictions.

Radha & Arumugam [7] established a new product called residue product and studied some properties regarding effectiveness, connection, and completeness. The vertex degree and total degree of residue product are obtained. The regularity condition for residue product is determined. Also, they have shown that the lexicographic max product is nothing but the direct sum of the maximal and residue product of FGs.

Muzzamal Sitara et al. [8] examined the maximal product and its notions of FG structure. Also, they constituted the conditions to prove regularity with examples. The degree and total degree of maximal product are executed and the results are furnished. Finally, a figure and flowchart are presented for the FG structure to analyze an application about controversial issues among countries.

3. Various Product Approaches on Intuitionistic Fuzzy Graphs

The generalization of FG with the inclusion of another membership helps researchers extend their product operations to Intuitionistic fuzzy graphs, listed below in Table 2.

Table 2. Several types of products in an intuitionistic fuzzy graphical environment.

Reference	Year	Graph Type	Findings/Approaches
[9]	2009	Intuitionistic Fuzzy Graph (IFG)	Operations on IFG such as union, join, Cartesian Product, and composition are formulated with some properties.
[10]	2015		Direct product, semi-strong product, and strong product operations are done and a wide discussion on product IFG is implemented.
[11]	2015		The level counterparts demonstrate a direct, lexicographic, and strong product on IFG and treat them with some categorical goodness.
[12]	2017		Cartesian, composition, tensor, and normal product are designed on IFG and vertex degree is analyzed with all these product operations.
[13]	2017		Introduction of a regular property on the cartesian product of IFG is given and some basic theorems are framed.
[14]	2018		A co-normal product of IFG is taken and proved to have complete and regular properties.
[15]	2019		The max product on IFG is furnished and checked for vertex degree property based on regularity.
[16]	2019	Bipolar IFG	Well-known products such as Cartesian, composition, tensor, and normal product on bipolar IFG are drawn and their vertex degree is determined.

[17]	2020	IFG	Lexicographic min and max products on IFG are newly executed and checked for effective and connected properties. In addition, the vertex degree and relationship between these products are analyzed.
[18]	2021	Intuitionistic Fuzzy Incidence Graph (IFIG)	Cartesian, composition, tensor, and normal product in IFIG with the vertex degree calculation is included and an application in the textile industry with the Cartesian product and composition is figured out.
[19]	2021	IFG	Complementation on the max product of IFG is found and dealt with regularly. Also, an application is provided to select a suitable school for students.
[20]	2021	Complex IFG	Direct, semi-strong, strong, and modular products on complex IFG are enquired and some approaches are done.
[21]	2023	Intuitionistic Anti-Fuzzy Graph (IA-FG)	A new conformal product on IA-FG is introduced, and properties like complete, regular, etc. are applied. An application to enhance product quality and decrease supermarket costs is discussed.

Parvathi et al. [9] accomplished the IFG and learned some complementary properties & theorems of IFG. Also, implementing various products like union, join, cartesian product, and composition on IFG is defined, and its properties are learned in detail.

Sankar Sahoo and Madhumangal Pal [10] developed direct, semi-strong, and strong products of two IFGs and obtained many results. In addition, the product IFG is observed, and its implementation with the product gives rise to new innovative output.

Hossein Rashmanlou et al. [11] explored the rationality of some product operations, such as direct, lexicographic, and strong, on IFG. The rational demonstration of these product notions is done by characterizing the graph's level counterpart. The category theory is used to extinguish some categorical properties.

Sankar Sahoo & Madhumangal Pal [12] newly defined the normal and tensor product. Furthermore, the degree of some products was learned, and their properties are exemplified.

Nagoor Gani and Sheik Mujibur Rahman [13] observed the regular condition of the cartesian product of IFG. Of the IFGs taken for the product, either both are considered regular or one is totally regular and another partially regular. They finalized the functions as constant by keeping the product graph and one of the graphs regular and the other partially regular.

Kalaiarasi & Mahalakshmi [14] defined the co-normal product on IFG and proved that the product is again an IFG. Their analysis on a complete, regular, pseudo-regular, totally regular, and pseudo-regular property has been carried out briefly in some cases.

Yahya Mohamed & Mohamed Ali [15] approached the max-product of IFG with the vertex degree and regularity conditions using constant functions.

Sonia Mandal & Madhumangal Pal [16] chose bipolar IFG to apply some operations namely cartesian product, composition, tensor product, and normal product. The resultant graphs of these products are analyzed for their vertex degree.

Syamala & Balasubramanian [17] considered the lexicographic min product & lexicographic max product and these operations are checked for connected and effective properties. The degree of a vertex is found for both operations. Also, the relationship between these products is proved by theoretical proof.

Irfan Nazeer et al. [18] presented the cartesian, composition, tensor, and normal product on IFIG, and the vertex degree-based discussion is rendered for these product operations. A real-life application of cartesian product and composition is produced that concerns departments of various branches of the textile industry. A comparative analysis shows the difference between the proposed and previous models.

Yahya Mohamed & Mohamed Ali [19] initiated the definition of max product on IFG and their complementation. Also, the vertex degree for this complementation of the max product on IFG is given. This idea is also applied to regular IFG. An application to determine the school based on entrance marks is provided and is processed using the Normalized Hamming Distance method.

Abida Anwar & Faryal Chaudhry [20] applied key operations like direct, semi-strong, strong, and modular products on complex IFG. Some theoretical results are obtained while applying properties like strong, complete, etc.

Kalaiarasi et al. [21] execute the conormal product on IA-FGs. Also, this product has been implemented to complete, regular, and strong IA-FGs. An application that relates the product quality and cost of the supermarket goods is explained in brief.

4. Several Product Discussions on Neutrosophic Graphs

The enrichment related to the concern of graph product in a neutrosophic environment is listed in Table 3.

Table 3. Types of products in the neutrosophic graphical environment.

Reference	Year	Graph Type	Findings/Approaches
[22]	2017	Single Valued Neutrosophic Graph (SVNG)	Fundamental products like Cartesian, composition, union, join, cross, lexicographic, and strong products are considered in SVNG and proved with some basic outputs. Application concerns to people's thinking influence on others is exemplified.
[23]	2018	Neutrosophic Cubic Graph (NCG)	The Cartesian, composition, union, and join of neutrosophic cubic graphs have been found. Decision-making application for industry performance is included.
[24]	2020	m-polar SVNG	The graph model on the m−polar SVNG is developed and union, join, composition, ring sum, etc. are checked for two m−polar SVNGs. It is applied to evaluate college teacher performance.
[25]	2020	Bipolar SVNG	The residue product, rejection, maximal product, and symmetric difference operations on Bipolar SVNG are specified with some examples. Also, the vertex and vertex total degrees of Bipolar SVNG are found. This study is finalized with an application and algorithm to get seated in an educational designation.
[26]	2020	Derivable SVNG	KM-single valued neutrosophic metric graphs are taken and operations such as tensor product, Cartesian product, semi-strong product, strong product, union, semi-ring sum, suspension, and complement are applied.
[27]	2020	Neutrosophic Vague Graph (NVG)	NVG is constructed and a clear investigation of products such as Cartesian, lexicographic, cross, strong, and composition on NVG are investigated with examples.
[28]	2020	Strong SVNG	Products like a cross, semi-strong, strong, Cartesian, and composition are done on strong SVNG.
[29]	2021	Neutrosophic Graph (NG)	The maximal product, rejection, symmetric difference, and residue product operations are carried out with some examples. Also, the degree and the total degree of these

			products are analyzed. A decision-making problem to select the best hotel is provided as an application.
[30]	2021	SVNG	The following products are taken in a SVNG: Rejection, maximal product, symmetric difference, and residue product. An algorithm was used to illustrate an application related to the company selection by the Food and Agricultural Organization (FAO).
[31]	2022	NG	Operations using Cartesian product, composition, join, direct, lexicographic, and strong product are widely discovered on NG.
[32]	2022	Neutrosophic Vague Soft Graph (NVSG)	Products like Cartesian, cross, lexicographic, composition, and strong product on NVSG are taught with an application to select optimal object selection.
[33]	2022	Quadripartitioned Bipolar SVNG	The quadripartitioned bipolar SVNG is newly accomplished and some operations like cartesian, cross, lexicographic, strong product, and composition are done with suitable examples.
[34]	2023	SVNG	The max product of 3 SVNG is flourished with some theorem results and social network application is provided.
[35]	2023	SVNG	The domination concept on some operations of SVNG is proven with a symmetric difference application.
[36]	2023	SVNG	SVNG performs the rejection, symmetric difference, maximal product, and residue product operations. In a neutrosophic environment, a modified Boruvka algorithm solves the minimum spanning tree problem.
[37]	2024	Complex NG	Some processes of cartesian, union, join, and composition are achieved over complex NG, and a real-life application for hospital infrastructure design is emphasized.

Muhammad Akram & Gulfam Shahzadi [22] clearly defined SVNG, and some operations like Cartesian, composition, union, join, cross, lexicographic, and strong product are defined and discussed in detail. Also, some essential properties of SVNG by level graphs are flourished. The social behavioral characteristics like domination and influence among people are studied and the most characteristic persons are identified using SVNG.

Muhammad Gulistan et al. [23] developed the NCG concept from neutrosophic cubic sets and invigorated some binary product operations like cartesian, composition, union, and join, which are implemented for NCGs. In addition, the order and degree of NCG are illustrated with some examples. The authors enhanced the NCG concept with real-life situations and data by considering industrial applicability and criterion.

Kartick Mohanta et al. [24] modeled the m-polar neutrosophic graph and worked out some operations like strong, semi-strong, complete, direct, etc. in this model. Ideas such as complement, and isomorphism properties are implemented in this model. The college teacher's performance is evaluated using this model.

Aslam Malik et al. [25] picked up the bipolar SVNG and learned some executions of residue, rejection, maximal, and symmetric difference. A brief interaction on the vertex degree and total degree of bipolar SVNG is done. A real-world application to estimate the designation in educational education is portrayed.

Mohammad Hamidi & Florentin Smarandache [26] innovated a concept named KM-single valued neutrosophic metric graphs and elaborated on its properties. Also, a finite metric is applied over KM-fuzzy metric space, and through the obtained results various product operations such as tensor, semi-strong, semi-ring sum, union, and join, etc. are found concerning KM-single valued neutrosophic metric graphs.

Satham Hussain et al. [27] worked with the NVG and implemented some product aspects such as cartesian, cross, lexicographic, strong, and composition on NVG.

Shakthivel et al. [28] contemplated the strong SVNG and applied some products such as cross, semi-strong, strong, cartesian, and composition on strong SVNG.

Kartick Mohanta et al. [29] investigated new operations like rejection, symmetric difference, maximal product, and residue product on SVNG. Also, they excavated the application to select the best hotel using decision-making. Also, the concepts of these products' vertex degrees and total degrees are listed.

Shouzhen Zeng et al. [30] described the key features of rejection, maximal product, symmetric difference, and residue product of SVNG. An overview of the strong, complete, and connected properties of these SVNG products is explored. Also, the products' vertex degree and total degree are illustrated under specific conditions. The FAO of the United Nations selects the most suitable company using decision-making, which is provided as an application.

Arindam Dey et al. [31] clearly defined neutrosophic graph properties like regular, complete, etc. The SVNG is treated with features like cartesian, composition, lexicographic, join, direct, and strong product.

Satham Hussain et al. [32] observed key operations like cartesian, cross, lexicographic, strong product, and composition on NVSG. A decision-making application is viewed to select the most appropriate institution with good rankings.

Satham Hussain et al. [33] established a new theory called "Quadripartitioned Bipolar SVNG" and applied some basic operations, such as cartesian, cross, lexicographic, strong, and, composition.

Meenakshi & Mythreyi [34] extended the max product and its application in a neutrosophic environment to three SVNGs. Also, an application and example concerning a company's social networking scenario are provided along with a minimal spanning tree algorithm as additional information.

Meenakshi et al. [35] represented the domination number and dominating set for some operations like lexicographic, symmetric difference, residue, and max product. Here, a useful to analyze the productive optimal network is given by considering a single-valued neutrosophic network and symmetric difference. An algorithm to find an optimal network is customized.

Arindam Dey et al. [36] presented SVNG with some preliminary definitions, where some basic properties are discussed. Some SVNG operations such as rejection, symmetric difference, maximal, and residue product are reviewed. Some important theorems based on degree and total degree are investigated in these operations. Also, Boruvka's algorithm of classical type is altered to meet the minimum spanning tree in a neutrosophic environment.

Mohammed Alqahtani et al. [37] put forth an immense applied work with complex environmental neutrosophic graphs. Some key operations like cartesian, union, join, and composition are implemented with complex neutrosophic graphs. In addition, isomorphism and complement properties of this specialized graph are discussed. Finally, an application that deals with hospital infrastructure design in the suitable starting area prepared by healthcare planners is portrayed.

5. Conclusion

Adaptability and enforcement have been achieved in the neutrosophic type of graph product discussion since it claims improvised and refined results compared to the previous fuzzy-related works. The ambiguity is analyzed well in the neutrosophic structure, which improves the final output in terms of accuracy. This analysis navigates the complexities and gives a clear view of the updated works, which suit the current environment and scope. The challenges that occurred during practical implications are avoided due to the exploration of neutrosophic graph theory as it deals with indeterminacy in a segregated manner. Future models can be devised using neutrosophic theory since it improves practical execution.

Declarations

Ethics Approval and Consent to Participate

The results/data/figures in this manuscript have not been published elsewhere, nor are they under consideration by another publisher. All the material is owned by the authors, and/or no permissions are required.

Consent for Publication

This article does not contain any studies with human participants or animals performed by any of the authors.

Availability of Data and Materials

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Competing Interests

The authors declare no competing interests in the research.

Funding

The article has been written with the joint financial support of RUSA-Phase 2.0 grant sanctioned vide letter No.F.24-51/2014-U, Policy (TN Multi-Gen), Dept. of Edn. Govt. of India, Dt. 09.10.2018, UGC-SAP (DRS-I) vide letter No.F.510/8/DRS-I/2016(SAP-I) Dt. 23.08.2016 and DST (FIST - level I) 657876570 vide letter No.SR/FIST/MS-I/2018/17 Dt. 20.12.2018.

Author Contribution

All authors contributed equally to this research.

Acknowledgment

The author is grateful to the editorial and reviewers, as well as the correspondent author, who offered assistance in the form of advice, assessment, and checking during the study period.

References

1. Mordeson, J.N., & Chang-Shyh, P. (1994). Operations on Fuzzy Graphs, Information Sciences, 79(3-4), 159-170. https://doi.org/10.1016/0020-0255(94)90116-3.
2. Nagoor Gani, A., & Radha, K. (2008). Conjunction of Two Fuzzy Graphs, International Review of Fuzzy Mathematics, 3(1), 95-105.
3. Nagoor Gani, A., & Fathima Kani, B. (2014). Beta and Gamma Product of Fuzzy Graphs, Intern. J. Fuzzy Mathematical Archive, 4(1), 20-36.
4. Radha, K., & Arumugam, S. (2014). On Strong Product of Two Fuzzy Graphs, International Journal of Scientific and Research Publications, 4(10), 1-6.
5. Radha, K., & Arumugam, S. (2015). On Maximal Product of Two Fuzzy Graphs, International Journal of Current Research, 7(1), 11508-11515.
6. Dogra, S. (2015). Different Types of Product of Fuzzy Graphs, Progress in Nonlinear Dynamics and Chaos, 3(1), 41-56.
7. Radha, K., & Arumugam, S. (2015). On residue product of two fuzzy graphs, International Journal of Multidisciplinary Research and Development, 2(11), 221-227.
8. Sitara, M., Akram, M., & Yousaf Bhatti, M. (2019). Fuzzy Graph Structures with Application, Mathematics, 7(1):63, 1-22. https://doi.org/10.3390/math7010063.
9. Parvathi, R., Karunambigai, M.G., & Atanassov, K.T. (2009). Operations on intuitionistic fuzzy graphs, 2009 IEEE International Conference on Fuzzy Systems, Jeju, Korea (South), pp. 1396-1401. https://doi.org/10.1109/FUZZY.2009.5277067.
10. Sankar Sahoo & Madhumangal Pal. (2015). Different types of products on intuitionistic fuzzy graphs, Pacific Science Review A: Natural Science and Engineering, 17(3), pp. 87-96, ISSN 2405-8823, https://doi.org/10.1016/j.psra.2015.12.007.

11. Rashmanlou, H., Samanta, S., Pal, M., & Borzooei, R. A. (2015). Intuitionistic Fuzzy Graphs with Categorical Properties, Fuzzy Information and Engineering, *7*(3), 317–334. https://doi.org/10.1016/j.fiae.2015.09.005.
12. Sankar Sahoo & Madhumangal Pal. (2017). Product of intuitionistic fuzzy graphs and degree, Journal of Intelligent & Fuzzy Systems, 32(1), pp. 1059-1067. https://doi.org/10.3233/JIFS-16348.
13. Nagoor Gani, A., Sheik Mujibur Rahman, H. (2017). Totally Regular Property of Cartesian product of Intuitionistic Fuzzy Graphs, Advances in Fuzzy Mathematics, 12(1), pp. 63-76.
14. Kalaiarasi. K., & Mahalakshmi, L. (2018). On Co-normal product of Two Intuitionistic Fuzzy Graphs, International Journal of Pure and Applied Mathematics, 120(5), pp. 1321-1335.
15. Yahya Mohamed, S., & Mohamed Ali, A. (2019). Degree of a Vertex in Max-Product of Intuitionistic Fuzzy Graph, International Journal of Recent Technology and Engineering (IJRTE), 8(4), pp. 2902-2905. https://doi.org/10.35940/ijrte.C6411.118419.
16. Mondal, S., & Pal, M. (2019). Product of Bipolar Intuitionistic Fuzzy Graphs and Their Degree, TWMS J. App. Eng. Math. 9(2), pp. 327-338.
17. Syamala, P., & Balasubramanian, K.R. (2020). On Lexicographic Products of Two Intuitionistic Fuzzy Graphs, J. Math. Comput. Sci, 10(1), pp. 136-149. https://doi.org/10.28919/jmcs/4311.
18. Irfan Nazeer, Tabasam Rashid & Abazar Keikha. (2021). An Application of Product of Intuitionistic Fuzzy Incidence Graphs in Textile Industry, Complexity, Volume 2021, Article ID 5541125, 16 pages https://doi.org/10.1155/2021/5541125.
19. Yahya Mohamed, S., Mohamed Ali, A. (2021). Complement of max product of intuitionistic fuzzy graphs, Complex & Intelligent Systems, https://doi.org/10.1007/s40747-021-00438-2.
20. Abida Anwar & Faryal Chaudhry. (2021). On Certain Products of Complex Intuitionistic Fuzzy Graphs, Journal of Function Spaces, Volume 2021, Article ID 6515646, 9 pages. https://doi.org/10.1155/2021/6515646.
21. Kalaiarasi, K., Mahalakshmi, L., Nasreen Kausar., & Saiful Islam. A. B. M. (2023). Conormal Product for Intutionistic Anti-Fuzzy Graphs, International Journal of Fuzzy Logic and Intelligent Systems, 23(1), pp. 79-90. http://doi.org/10.5391/IJFIS.2023.23.1.79.
22. Akram, M., & Shahzadi, G. (2017). Operations on Single-Valued Neutrosophic Graphs, Journal of uncertain systems, 11(1), pp. 1-26.
23. Gulistan, M., Yaqoob, N., Rashid, Z., Smarandache, F., & Wahab, H.A. (2018). A Study on Neutrosophic Cubic Graphs with Real Life Applications in Industries, Symmetry, 10(6): 203. https://doi.org/10.3390/sym10060203.
24. Mohanta, K et al. (2020). A study of m−polar neutrosophic graph with applications, Journal of Intelligent & Fuzzy Systems, 38(4), pp. 4809–4828. https://doi.org/10.3233/JIFS-191520.
25. Aslam Malik, M et al. (2020). A Study on Bipolar Single-Valued Neutrosophic Graphs With Novel Application, Neutrosophic Sets and Systems, Vol. 32, pp. 221-268. https://doi.org/10.5281/zenodo.3723630.
26. Hamidi, M., & Smarandache, F. (2020). Derivable Single Valued Neutrosophic Graphs Based on KM-Fuzzy Metric, In IEEE Access, vol. 8, pp. 131076-131087. https://doi.org/10.1109/ACCESS.2020.3006164.
27. Satham Hussain, S., Jafari, S., Broumi, S., & Durga, N. (2020). Operations on Neutrosophic Vague Graphs, Neutrosophic Sets Syst., Vol. 35, pp. 368-386. https://doi.org/10.5281/zenodo.3951686.
28. Shakthivel, R., Vikramaprasad, R., & Vinothkumar, N. (2020). Products on Strong Single Valued Neutrosophic Graphs, TEST Engineering & Management, ISSN: 0193-4120, pp. 20063 – 20073.
29. Mohanta, K., Dey, A., Pal, A. (2021). A note on different types of product of neutrosophic graphs, Complex & Intelligent Systems, 7:857–871. https://doi.org/10.1007/s40747-020-00238-0.
30. Zeng, S., Shoaib, M., Ali, S., Smarandache, F., Rashmanlou, H., & Mofidnakhaei, F. (2021). Certain Properties of Single-Valued Neutrosophic Graph With Application in Food and Agriculture Organization, International Journal of Computational Intelligence Systems, Vol. 14(1), pp. 1516–1540. https://doi.org/10.2991/ijcis.d.210413.001.
31. Dey, A., Kumar, R., Broumi, S., & Bhowmik, P. (2022). Different Types of Operations on Neutrosophic Graphs, International Journal of Neutrosophic Science, Vol. 19, No. 02, pp. 87-94. https://doi.org/10.54216/IJNS.190208.
32. Satham Hussain, S., Jahir Hussain, R., Muhiuddin, G., & Anitha, P. (2022). Operations on Neutrosophic Vague Soft Graphs, Neutrosophic Sets Syst., Vol. 51, pp. 254-268. https://doi.org/10.5281/zenodo.7135287.

33. Satham Hussain, S., Muhiuddin2, G., Durga, N., & Al-Kadi, D. (2022). New Concepts on Quadripartitioned Bipolar Single Valued Neutrosophic Graph, Computer Modeling in Engineering & Sciences, vol.130, no.1, pp. 559-580. https://doi.org/10.32604/cmes.2022.017032.
34. Meenakshi, A., & Mythreyi, O. (2023). Applications of Neutrosophic social network using max product networks, Journal of Intelligent & Fuzzy Systems, 45, pp. 407–420. https://doi.org/10.3233/JIFS-223484.
35. Meenakshi, A., Mythreyi, O., Bramila, M., Kannan, A., & Senbagamalar, J. (2023). Application of neutrosophic optimal network using operations, Journal of Intelligent & Fuzzy Systems, 45, pp. 421–433. https://doi.org/10.3233/JIFS-223718.
36. Dey, A., Mohanta, K., Bhowmik, P., & Pal, A. (2023). A study on Single Valued Neutrosophic Graph and its application, Research Square, pp. 1-26. https://doi.org/10.21203/rs.3.rs-2421528/v1.
37. Alqahtani, M., Kaviyarasu, M., Al-Masarwah, A., & Rajeshwari, M. (2024). Application of Complex Neutrosophic Graphs in Hospital Infrastructure Design, Mathematics, 12, 719. https://doi.org/10.3390/math12050719.

Received: 01 Jun 2024, **Revised:** 26 Sep 2024,

Accepted: 27 Oct 2024, **Available online:** 01 Nov 2024.