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Integrating Fuzzy Graceful Labeling for Enhanced Prediction of *UV* Radiation Intensity in Holography

J. Senbagamlar[1] . P. Devika[2]. Hossein Rashmanlou[3]. Farshid Mofidnakhaei[4]

[1] Department of Mathematics, Vel Tech Rangarajan Dr. Sagunthala R&D Institute of Science and Technology, Chennai – 600062, India;
Corresponding Author E-mail: drsenbagamalarj@veltech.edu.in; vtd1608@veltech.edu.in
[2] Department of Mathematics, Vel Tech Rangarajan Dr. Sagunthala R&D Institute of Science and Technology, Chennai – 600062, India;
E-mail: pdevikagopiraj@gmail.com
[3] Canadian Quantum Research Center, 106-460 Doyle Ave, Kelowna, British Columbia V1Y 0C2, Canada;
E-mail: rashmanlou.1987@gmial.com
[4] Department of Physics, Sar.C., Islamic Azad University, Sari, Iran;
E-mail: farshid.mofidnakhaei@gmail.com

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Abstract. The multiple classes of graphs that can be labeled gracefully are defined using the principles of neutrosophy. By imposing structural and labeling constraints on the graph, it becomes possible to define the n-th position uniquely under neutrosophic fuzzy conditions. The variety of vertex labels and edge labels may coincide for more than one vertex, and a complete proof of existence is provided for the neutrosophic fuzzy labeling of the graphs discussed in this research. Using the neutrosophic fuzzy framework, all three forms of uncertainty in the labeling process are effectively represented. In this work, neutrosophic fuzzy graceful labeling is further connected to applications involving UV rays generated from a point source and holography. The uncertainty-handling capability of neutrosophic fuzzy labeling allows it to model imprecise intensity variations of UV radiation and the wave-interference patterns fundamental to holographic reconstruction. Thus, we develop a systematic method for applying the neutrosophic fuzzy framework to network design, routing, and optimization problems, as well as to holographic encoding where labeling consistency and uncertainty coexist. In addition to providing representations of the proposed neutrosophic fuzzy labeling framework for selected graph families, the paper demonstrates that labeling constraints can yield consistent graph while managing uncertainty associated with complex physical inputs such as UV propagation and holographic wave patterns. Compared to classical graceful labeling, neutrosophic fuzzy labeling offers enhanced capability to incorporate and handle imprecise, fluctuating, and partially known data. This study lays the foundation for future theoretical refinement and future algorithm development for neutrosophic fuzzy graph labeling with respect to the graceful constraints relating to optical modeling, UV radiation analysis, and holographic systems.

Keywords: Neutrosophic Fuzzy Graph; Ultraviolet Radiation; Holography; Uncertainty; UV Propagation.

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1 Introduction

This study uses digital holographic interferometry to examine the impact of varying ultraviolet radiation levels on human skin. The impact of UV exposure is measured using the changes in skin firmness and movement depicted in pseudo-3D images. Zadeh presented the idea of fuzzy relations to model the theme, which coincides with the ideas of ambiguity and uncertainty in exciting member are several uses for fuzzy relations in pattern recognition and the graph labelling technique [1]. Graph labelling is a procedure that consists of assigning a function that associates elements from a set of vertices, edges, or both. onto a collection of labels. In a variety of areas, graph labelling has been useful and, depending on the circumstances of labelling, can lead to various labels [2,3]. Among the most common are elegant and beautiful labels and authors S. Broumi and F. Smarandache addressed the instance of neutrosophic graphs with a single value by representing the degree of SVNG [4]. In a graph labelling, the vertex and edge variables have discussed graceful labelling and explored it deeply in the contributions and discussions in the graphs where a function has been defined from V_i to set S of labels are vertex-labelled graphs and graphs where a function has been defined from E_i to set S of labels are edge-labelled graphs [5,6]. Some careful developments of old ideas are intended to provide a certain reliability since the graphical method sometimes generates confused and contradictory results and we obtain the Mycielski graph of the path graph $\mu(P_n)$ by adding edges from each vertex $u_i \in U$ to the matching vertex v_i in G_i that is next to vertices v_j and connecting each $u_i \in U$ to the vertex w_0 [7-9]. The graph $H(n,k)$ is arbitrate in a set of peaks formed from Σ^n, where Σ is an alphabet of size k and if there is exactly one coordinate difference between two vertices, then they are connected, then potentials of ideal circulant for applications that are communication intensive and discover the strengths of cartesian products [10,11]. The application domain of fuzzy sets and neutrosophic sets differs slightly, as can be seen when comparing their respective applications of neutrosophic set works with ambiguous and inconsistent information, fuzzy set deals with incomplete and imprecise, or unsure, information, the key area of mathematics called graph theory uses vertices, or nodes, and edges, or links, to represent relationships inside networks [12,13]. A graph is a helpful notion that can employ edges to indicate relationships or state transitions between ideas of graph theory has been thoroughly studied in many areas, including practical applications, due to its significance, to enhance the theoretical foundation and practical usability of graph labelling techniques across multiple domains. The basis of numerous fundamental ideas in fuzzy labeling, wherein an association is established that allocates numerical labels to the elements of a graph. In irrefutable pattern of tree, the binomial tree B_{ik} is made up dual linked binomial trees $B_{ik} - 1$, with the primary root of the other being the farthest left child of the starting node of the other tree and the binomial tree of order k, has 2^k vertices that every binomial tree is elegant and graph immersion parameter by giving definitions for Mycielski graphs and generalized Mycielski graphs theorem, the characteristic of being triangle-free is called the Mycielski graph of an undirected graph [14,15]. The set $\{\partial, \partial+1, \dots, \rho\}$ is represented by $[\partial, \rho]$ for two positive integers ∂ and ρ with $\partial \leq \rho$. Let G_1 and G_2 be graphs. The cartesian product G_{i1} and G_{i2} is as follows $V_i(G_{i1}) \blacksquare V_i(G_{i2}) = V_i(G_{i1})\, X\, V_i(G_{i2})$, by combining three different components T, I and F neutrosophic sets are better able to convey the complexities of uncertain knowledge to improve the capacity to represent and evaluate data with greater complexity and ambiguity [16]. The neutrosophic cordial fuzzy labeling and neutrosophic magic fuzzy labeling was demonstrated for particular graphs [17,18]. Neutrosophic fuzzy labeling is correlated with fuzzy network [19]. The neutrosophic fuzzy hamming graph using resolvent number which can be connected with images [20]. In this paper obtain the neutrsphic graceful labeling is correlated with holography UV rays.

2 Methodology

Digital Holographic Interferometry is applied to create holograms of a sample both prior and post to exposing the sample to UV light. The reconstructed phase maps are transformed into a plot. Also, in conjunction with that transformation, applying Neutrosophic Fuzzy Graceful Labelling to the phase maps allows for the modelling of truth, uncertainty, and falsehood in the changes. Through this combined methodology, we are able to examine with accuracy any deformity that occurs, while navigating any uncertainty surrounding it.

3 Preliminary

This study surveys multiple constructive approaches for generating graphs that satisfy neutrosophic fuzzy graceful labelling, detailing the labelling rules, existence proofs, and structural implications across diverse graph classes, and illustrating practical application in uncertainty aware network design.

Definition 3.1 Assume $X_i= \left\{\chi_{i1,}\chi_{i2,}\cdots,\chi_{in}\right\}$ represents a collection of elements within the universe. A fuzzy set labeled A_i associated with the realm can be written as $A_i= \left\{\left(\chi_{i,}\mu_{A_i}(\chi_i)\right) \mid i=1,2,\ldots,n\right\}$, such that $\mu_A: X_i \rightarrow [0,1]$ is the function indicating degree. For each component $\chi_{i,} \in X_i$, the value $\mu_{A_i}(\chi_i) \in [0,1]$ indicates the extent to which χ_i is a member associated with fuzzy set A_i.

Definition 3.2 The graph G_i is called a fuzzy-valued graph if it is described by the tuple of functions (σ_i,μ_i) where $\sigma: V \rightarrow [0,1]$ gives a membership value for each vertex in a set with one or more elements set V_i, and $\mu: V_i\ X\ V_i \rightarrow [0,1]$ assigns a membership value for each possible edge between any two vertices $u,v \in V_i$. These satisfy the constraint $\mu(u,v) \leq \min(\sigma(u),\ (\sigma_i(v))\ \forall\ u,v \in V_i$

Definition 3.3 Let U act as the domain of discourse and let $A_i \subseteq U$. Then the neutrosophic set A_i is given by $A_i=\left\{\langle x_i,\ T_{A_i}(x_i), I_{A_i}(x_i), F_{A_i}(x_i)\rangle \mid x_i \in U\right\}$, where $T_{A_i}(x_i), I_{A_i}(x_i), F_{A_i}(x_i): U \rightarrow [0,1]$ denote the degree of truth- membership, the degree of indeterminacy-membership and the degree of falsity-membership of x_i in A_i, respectively. These three values are independent of one another and satisfy the bound $0 \leq T_{A_i}(x_i) + I_{A_i}(x_i) + F_{A_i}(x_i) \leq 3$, for every $x_i \in U$.

Definition 3.4 Let d, q be positive integers. The graph $H(d,q)$ as its node set all ordered sequences of length d ,$\left(u_{i1,}\ u_{i2,}\ \ldots,\ u_{in,}\right)$ where each coordinate u_i is chosen from a set of size q. A pair of vertices with no common identity $(u_{i1}, u_{i2}, \ldots, u_{id,})$ and $(v_{i1}, v_{i2}, \ldots, v_{id,})$ are adjacent when the condition holds, they differ in exactly one coordinate.

Definition 3.5 A bijection is a function that assigns a value in the interval [0,1] to each vertex and edge of a graph G*. for every vertex is given a membership values and for each edge is assigned membership value such that $\mu(u_i,v_i) < \min(\sigma(u_i), (\sigma(v_i))$ for all vertices $u_i,v_i \in V_i$. A graph with such an assignment is called a fuzzy labeling graph and is denoted by G_i.

Definition 3.6 A neutrosophic graph G_i*= (V_i, σ_i, μ_i) is called a neutrosophic labeled graph if there exist functions T_1: $V_i \to [0,1], I_1$: $V_i \to [0,1], F_1$: $V_i \to [0,1]$ and T_2: $V_i\, X\, V \to [0,1], I_2$: $V_i\, X\, V_i \to [0,1], F_2$: $V_i\, X\, V_i \to [0,1]$ which are bijective, such that the truth-membership, indeterminacy-membership and falsity-membership functions of the vertices and edges are distinct, and for every edge $(v_{i,}v_j) \in E$.

$T_2(v_{i,}v_j) \leq min\{T_1(V_i), T_1(V_j)\}$,

$I_2(v_{i,}v_j) \leq min\,\{I_1(V_i), I_1(V_j)\}$,

$F_2(v_{i,}v_j) \leq max\{F_1(V_i), F_1(V_j)\}$,

$0 \leq T_2(v_{i,}v_j) + I_2(v_{i,}v_j) + F_2(v_{i,}v_j) \leq 3$

Definition 3.7 For positive integers t and n, the circulant graph $C_n(1,2,\ldots,t)$, is defined as a simple undirected graph with vertex $V_{i\,n} = (V_{i0}, V_{i1}, \ldots, V_{in-1})$, where the indices are considered modulo n. Each vertex V_i is contiguous to the vertices $V_{i-t}, V_{i-t+1,\ldots,}V_{i-1,}V_{i+1,\ldots,}V_{i+t-1,}V_{i+t}(mod\, n)$. The distance measured between any two nodes V_i and V_j in $G = C_N(1,2,\ldots,t)$ is expressed as $d_G(v_{i,}v_j) = \begin{cases} \left\lceil\frac{|i-j|}{t}\right\rceil, if\ |i-j| < \left\lceil\frac{n}{2}\right\rceil, \\ \left\lceil\frac{n-|i-j|}{t}\right\rceil, if\ |i-j| \geq \left\lceil\frac{n}{2}\right\rceil. \end{cases}$

4 Graceful Neutrosophic fuzzy labeling graph

Consider the neutrosophic fuzzy hamming graph, G_i=$(V_i, E_{\ i})$ in which every vertex $v_i \in V_i(G_i)$ has a membership value $T(v_i)$. When the membership values of any two adjacent vertices, v_i and v_j are different, $\forall\ T(v_{il}) \neq T(v_j)$, then the graph G_i satisfies the graceful labeling condition.

Theorem 4.1 The neutrosophic fuzzy hamming graph *H(n,k)* possesses a well-defined neutrosophic vertex graceful labeling.

Proof: Let us consider a neutrosophic fuzzy hamming graph *H(n,k)* . where the length of tuples d is 2 and number of elements q is 3. $V_i = \left\{\frac{n-2}{10}, \frac{n}{10}, \frac{n+2}{10}\right\}$, n is even The vertex starts from $V_i = \{H(n,k)\backslash 1 \leq n \leq k^n\}$ where the edges starts from $\mu(V_{i\alpha}, V_{i\beta}) = (T(V_{i\alpha}, V_{i\beta}), I(V_{i\alpha}, V_{i\beta}), \mathrm{F}(V_{i\alpha}, V_{i\beta})$ is (0.02,0.03,0.04)then $V_{i1} = \{V_i - \mu(V_{i\alpha}, V_{i\beta})\}$ Which consists of an edge set $\mu(V_{i\alpha}, V_{i\beta}) = \{E\backslash 1 \leq 2\mu(V_i, V_{il})\}$ such that $\mu(V_{i\alpha}, V_{i\beta}) > 0$ and $\mu(V_{i\alpha}, V_{i\beta+1}) > 0$, for Let V be the central vertex and other vertices are $\{V_{i1}, V_{i2}, \ldots, V_{i\,n}\}$ of the neutrosophic hamming graph. In a generalized neutrosophic fuzzy hamming graph $H(2,2)$, the central vertex v_i, labeling $\sigma_i: V_i \to [0,1]$ satisfies the condition that if each membership value, then the generalized neutrosophic fuzzy hamming graph is said to have neutrosophic vertex graceful labeling, admits neutrosophic fuzzy hamming graph.

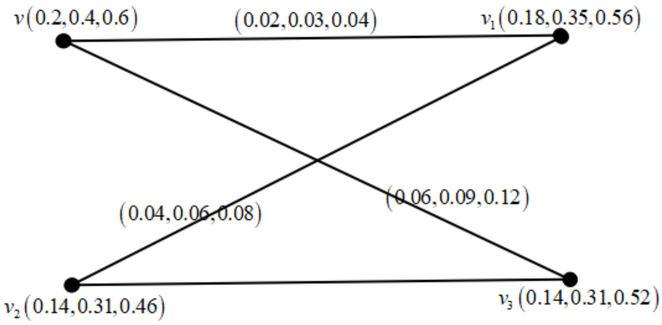

Figure 1: Hamming graph $H(2,2)$

The neutrosophic fuzzy hamming graph $H(2, 2)$ is shown in Fig. 1.

Theorem 4.2. The graph G_{i1} and G_{i2} attain the neutrosophic fuzzy labeling, then the cartesian product $G_{i1} \blacksquare G_{i2}$ permits a neutrosophic fuzzy cartesian product graceful labeling graphs.
Proof: Consider a pair of graphs G_{i1}, G_{i2}, $G_{i1}(V_i, E_i) \blacksquare G_2(V_i, E_i)$, $V_i = \left\{ \frac{n-2}{10}, \frac{n}{10}, \frac{n+2}{10} \right\}$, n is the natural numbers. The vertex starts from $V_i = \{ G_{i1} \,\&\, G_{i2} \backslash 1 \leq V_i \leq 2 \}$, where the edges starts from $\mu(V_{i\alpha}, V_{i\beta}) = (T(V_{i\alpha}, V_{i\beta}), I(V_{i\alpha}, V_{i\beta}), F(V_{i\alpha}, V_{i\beta})$ is (0.01,0,02,0,03) and $V_{i1} = \{V_i \text{-} \mu(V_{i\alpha}, V_{i\beta})\}$ Which consists of an edge set $\mu(V_{i\alpha}, V_{i\beta}) = \{E_i | 1 \leq 2\mu(V_{i\alpha}, V_{i\beta})\}$ such that $\mu(V_{i\alpha}, V_{i\beta}) > 0$ and $\mu(V_{i\alpha}, V_{i\beta+1}) > 0$. Let V_i denote designate one vertex as the central node and assign the other vertices to occupy the surrounding positions represented by $\{V_{i1}, V_{i2}, \ldots, V_{in}\}$. In a generalized neutrosophic fuzzy cartesian product graph, G_{i1} and G_{i2} central vertex V_i is labeling $\sigma_i : V_i \rightarrow [0,1]$ such that each membership value satisfies the prescribed conditions. The generalized neutrosophic fuzzy cartesian product graph is said to have neutrosophic vertex graceful labeling, admits neutrosophic fuzzy cartesian product graph.

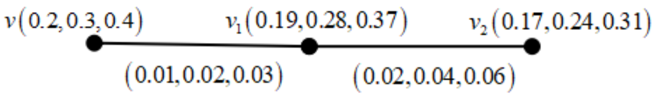

Figure 2 : The graph G_{i1}

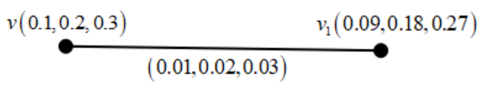

Figure 3: The graph G_{i2}

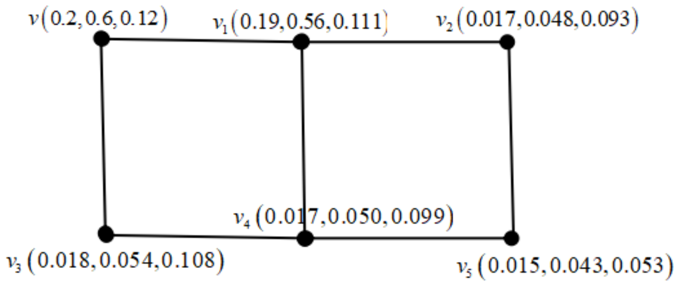

Figure 4: The graph G_{i1} ■ G_{i2}

The graphs G_{i1} and G_{i2} are in Fig. 2 and Fig. 3 and the cartesian product of G_{i1} and G_{i2} is presented in Fig.4.

Theorem 4.3 Every neutrosophic fuzzy circulant graph C_n attains gracefully labeling.
Proof: Consider a neutrosophic fuzzy circulant graph $C_n(V_{i1}, V_{i2}, \ldots, V_{in})$, $V_i = \left\{\frac{2n}{100}, \frac{2n-1}{100}, \frac{2n-2}{100}\right\}$ The vertex starts from $V_i = \{C_n | 1 \leq V_i \leq 2\}$, where the edges starts from $\mu(V_{i\alpha}, V_{i\beta}) = (TV_{i\alpha}, V_{i\beta}), I(V_{i\alpha}, V_{i\beta}, \mathrm{F}(V_{i\alpha}, V_{i\beta}))$ is (0.01,0.02,0.03) and $V_{i1} = \{V_i - \mu(V_{i\alpha}, V_{i\beta})\}$ which consists of an edge set $\mu(V_{i\alpha}, V_{i\beta}) = \{E_i | 1 \leq 2\mu(V_{i\alpha}, V_{i\beta})\}$ such that $\mu(V_{i\alpha}, V_{i\beta}) > 0$ and $\mu(V_{i\alpha}, V_{i\beta+1}) > 0$ for Let V be the central vertex and $\{V_{i1}, V_{i2}, \ldots, V_{in}\}$ denotes the other vertices of C_n. In a neutrosophic fuzzy circulant graph C_n, the central vertex V_i labeling $\sigma_i: V_i \to [0,1]$ satisfies the condition that if each membership value satisfied the prescribed condition. Then, the generalized neutrosophic fuzzy circulant graph is said to have neutrosophic vertex graceful labeling.

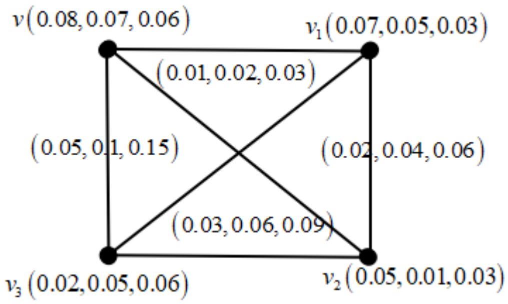

Figure 5: The circulant graph $C_4(1,2,3)$

The neutrosophic fuzzy circulant graph (C_5) is shown in Fig. 5.

Theorem 4.4 The neutrosophic Mycielski fuzzy preserves graceful labelling.
Proof: A neutrosophic fuzzy Mycielski graph will be examined, $M_n(V_{i1}, V_{i2}, \ldots, V_{in})$, $V_i = \left\{\frac{3n-3}{100}, \frac{3n}{100}, \frac{3n+3}{100}\right\}$. The vertex starts from $V_i = \{M_n / 1 \leq V \leq 2\}$, where the edges starts from $\mu(V_{i\alpha}, V_{i\beta}) = (T(V_{i\alpha}, V_{i\beta}), I(V_{i\alpha}, V_{i\beta}, \mathrm{F}(V_{i\alpha}, V_{i\beta}))$ is (0.02,0,03,0,04) and $V_{i1} = \{V_i - \mu(V_{i\alpha}, V_{i\beta})\}$ which consists of an edge set $\mu(V_{i\alpha}, V_{i\beta}) = \{E_i | 1 \leq 2\mu(V_{i\alpha}, V_{i\beta})\}$ such that $\mu(V_{i\alpha}, V_{i\beta}) > 0$ and $\mu(V_{i\alpha}, V_{i\beta+1}) > 0$. Let V_i be the central vertex and $\{V_{i1}, V_{i2}, \ldots, V_{in}\}$ denotes the other vertices of M_n. In a generalized neutrosophic fuzzy Mycielski graph M_n, the central vertex V_i labeling $\sigma_i: V_i \to [0,1]$ satisfies the condition that if each membership

value then the generalized neutrosophic fuzzy Mycielski graph is said to have neutrosophic vertex graceful labeling, admits neutrosophic fuzzy Mycielski graph.

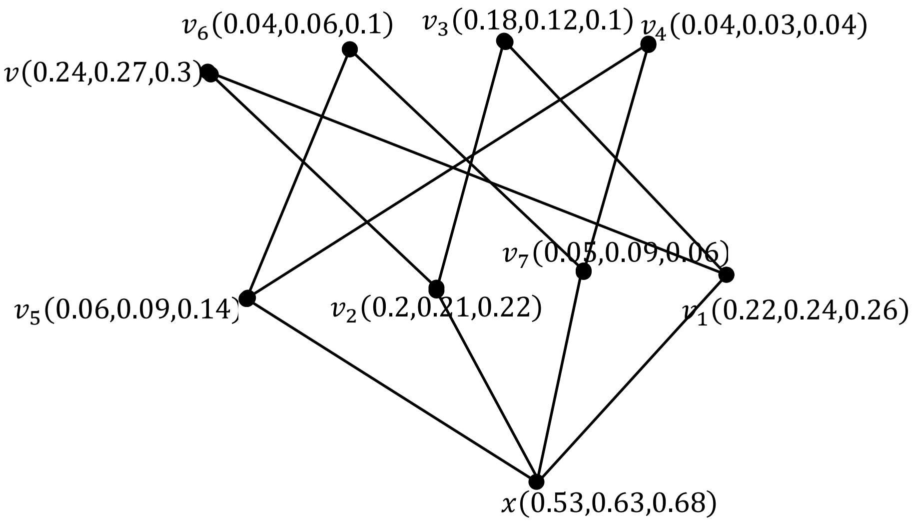

Figure 6: The Mycielski neutrosophic fuzzy graph for cycle C_4

In Fig. 6, shows the Mycielski construction for cycle C_4 .

Theorem 4.5. The neutrosophic fuzzy binomial treeB_{ik} preserves the graceful labelling.
Proof: Let us consider a neutrosophic fuzzy binomial treeB_{ik} graph $B_{ik}(V_{i1}, V_{i2}, \ldots, V_{i\,n})$, $V_i = \left\{\frac{4n-2}{100}, \frac{4n}{100}, \frac{4n+4}{100}\right\}$. The vertex starts from $V_i = \{B_{ik} | 1 \leq V_i \leq 2\}$, where the edges starts from $\mu(V_{i\alpha}, V_{i\beta}) = (T(V_{i\alpha}, V_{i\beta}), I(V_{i\alpha}, V_{i\beta}, \mathrm{F}(V_{i\alpha}, V_{i\beta}))$ is (0.01,0,02,0,03) and $V_{i1} = \{V_i - \mu(V_{i\alpha}, V_{i\beta})\}$ Which consists of an edge set $\mu(V_{i\alpha}, V_{i\beta}) = \{E_i | 1 \leq 2\mu(V_{i\alpha}, V_{i\beta})\}$ such that $\mu(V_{i\alpha}, V_{i\beta}) > 0$ and $\mu(V_{i\alpha}, V_{i\beta+1}) > 0$ for Let V_i be the central vertex and $\{V_{i1}, V_{i2}, \ldots, V_{i\,n}\}$ denotes the other vertices of B_{ik}. In a generalized neutrosophic fuzzy binomial treeB_{ik} graph the central vertex V_i labeling $\sigma_i: V_i \rightarrow [0,1]$ satisfies the condition that if each membership value then the generalized neutrosophic fuzzy binomial tree B_{ik} graph is said to have neutrosophic vertex graceful labeling, admits neutrosophic fuzzy binomial tree B_{ik} graph.

5. Real-Time Ultraviolet Ray Monitoring Based on Neutrosophic Fuzzy Graceful Labeling Technique

The present research involves the investigation of graphs that can be labelled gracefully using neutrosophic fuzzy rules. In the research, each vertex, representing a pole of *UV* rays, was assigned a label denoting the values of truth, indeterminacy, and falsehood. The result of using neutrosophic fuzzy logic produces meaningful network visits in cases where there is lost or undetermined data. The method is demonstrated to work satisfactorily even when some vertices and edges share vertex labels. Results indicate that neutrosophic fuzzy logic is repeatable, reliable, and credible for imprecision and uncertainty in tasks such as network design, routing, and optimization. The fuzzy labelling method is an advance to traditional graceful labelling, contributing useful and order-fair information regarding suspended UV rays. According to the world health organization, ultraviolet emission is classified into triple distinct variants based on wavelength, like *UVC*, spanning from 100 to 280 nm, UVB, extending across 280 to 315 nm and UVA, ranging from 315 to 400 nm. As in the Table 1, For analytical convenience in this study, the UV rays are modelled from a geometric standpoint. UV rays from natural and human-made sources propagate from one point in multiple complicated directions from other sources of UV light previously established. In terms of analyzing UV propagation in networks, this study employs a graph to represent the propagation of UV light, with neutrosophic fuzzy graceful labelling (NFGL), $f(V_i)$=(Ti,Ii,Fi), $f*(eij)$=($|Ti-Tj|$,$|Ii-Ij|$,$|Fi-Fj|$)). NFGL uses graph theory to describe the propagation of UV light from their source, preserving the structural component of the graph by assigning labels to each vertex and edge rather than maintaining a strict positive, and each piece of UV tilt is labelled distinctly.

Table 1: UV-based numerical parameters for holography.

Type	Energy level	Wave length range (nm)
UVC	Highest energy	100-280nm
UVB	Medium energy	280-315nm
UVA	Low energy	315-400nm

In this real time data collected from different scientific sources, the neutrosophic fuzzy set of ultra violet rays is UA=$\{\langle x_i, T_{A_i}(x_i), I_{A_i}(x_i), F_{A_i}(x_i)\rangle | \ x_i \in UA\}$, throughout this representation , the highest energy of the *UVC* rays taken as the truth membership values $T_{A_i}(x_i)$, the medium energy part of the *UVB* rays is taken as the indeterminacy membership values $I_{A_i}(x_i)$, and the lowest energy part of the *UVA* rays taken as the falsity membership values. The wave length range of ultraviolet rays is the ultraviolet spectrum is divided into three categories, *UVC* (100–280 nm), *UVB* (280–315 nm), and *UVA* (315–400 nm) Using digital holography, it is possible to visually observe how each *UV* type distorts a light wave, almost like watching the wave bend and deform in real time. This classification allows each wavelength category to be treated as an independent neutrosophic element distinguished by varying levels of truth, indeterminacy, and falsity. The wavelength ranges do not overlap, each belongs to a distinct energy domain, which satisfies the fundamental requirements of the neutrosophic fuzzy graceful labelling model which enables the distribution of ultraviolet radiation energies to be expressed using neutrosophic logic, assigning *UVC*, *UVB* and *UVA* to true, indeterminate and false respectively. The mathematical relation between the theoretical concepts of energy levels and the actual, measurable, physical energies of ultraviolet light through the use of real-time neutrosophic fuzzy-based measurements. In Table 2. each individual wavelength point is normalised to its membership function to facilitate additional analysis. The wavelength range of these components indicates the separate energetic domains requirements of the neutrosophic fuzzy graceful labelling model. The energy distribution of ultraviolet rays is represented in neutrosophic logic with *UVC*, *UVB* and *UVA* being assigned truth, indeterminacy and falsity respectively. The establishment of a correspondence provides a mathematical framework to link theory with observable phenomena in the real-time measurement of neutrosophic fuzzy values as shown in Table 2. Each specific wavelength point is normalized to its membership function to analysed the parameter. In Table. 1 and Table 2. demonstrates the mathematical abstraction and physical science can be interwoven to represent the energetic hierarchy of ultraviolet light in a logically structured and neutrosophically consistent manner.

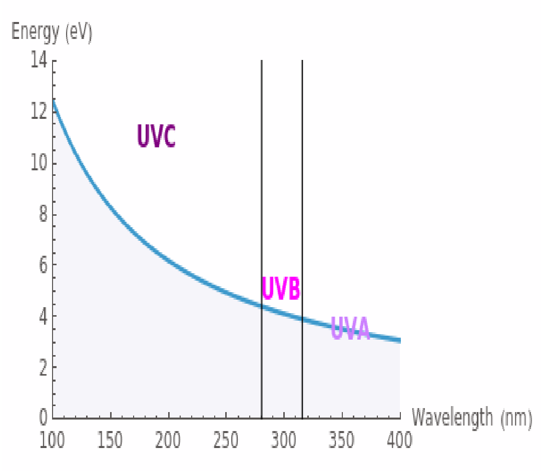

Figure 7 : The graphical representation of ultra violet rays

Table 2: Real-Time neutrosophic fuzzy values for *UVA*, *UVB*, and *UVC* based on energy intensity

λnm	$\mu(UVC)$	$\mu(UVB)$	$\mu(UVA)$
110	0.11	0	0
290	0	0.29	0
340	0	0	0.34

In Table 2. the real-time wavelength values of ultraviolet rays are converted into fuzzy membership values by dividing each wavelength by 1000 and these values match physically observe in digital holography. The normalization process provides a consistent basis for representing energy intensities within the neutrosophic fuzzy framework. For the wavelength 110 nm, the normalized value is 0.11 and in holography it produces the strongest distortion in the light wave which appears as very dense and sharp interference fringes. In this level, the highest-energy wavelength *UVC* is active, and hence its membership value is 0.11, while both *UVB* and *UVA* remain inactive with membership values of 0. When the wavelength 290 nm is divided by 1000, the resulting value 0.29 corresponds to the medium-energy wavelength *UVB*. Here, *UVB* alone exhibits activity, with $\mu(UVB)$ = 0.29, while *UVC* and *UVA* remain inactive and it creates a moderate distortion in the holographic pattern. For the wavelength 340 nm, dividing by 1000 yields 0.34, representing the lowest-energy wavelength *UVA*. In *UVA* component is active, and its membership value is 0.34, and holography confirms this by showing only minimal disturbance in the wavefront. whereas *UVC* and *UVB* have zero membership values. The pattern of values are distinct and non-overlapping values demonstrates triple wavelengths 110 *nm*, 290 *nm*, and 340 *nm* are mutually exclusive in their activity. Each wavelength occupies a unique energy domain and carries its own fuzzy membership, thereby satisfying the conditions of neutrosophic fuzzy graceful labelling. This reinforces the conceptual mapping between energy intensity and neutrosophic components of truth, indeterminacy, and falsity within the ultraviolet spectrum and *UVA* affects it the least. This agreement between mathematics and physical observation strengthens the reliability of the *NFGL* model.

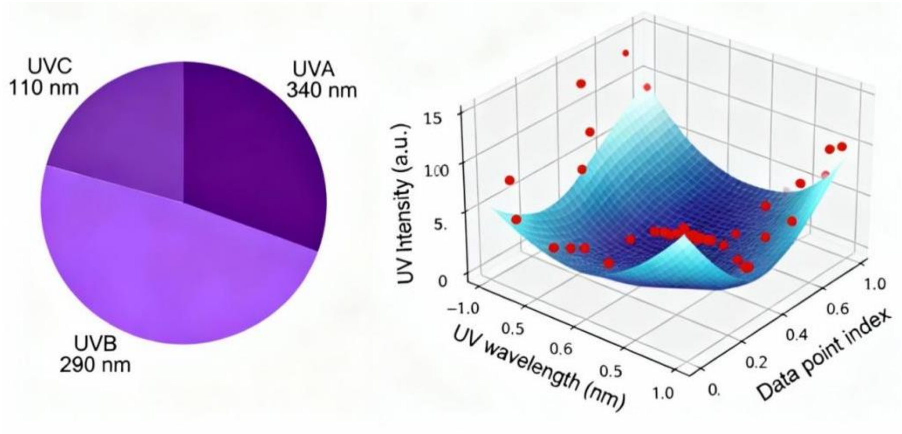

Figure 8: Real-time neutrosophic fuzzy values for *UVA*, *UVB*, and *UVC* based on energy Intensity *2D UV* rays into *3D* holography image

6 Neutrosophic Fuzzy Graceful Labelling in Ultraviolet Ray

The observation of *UV* wavelengths has a similar behavior in practical terms compared to the mathematical the principle of neutrosophic fuzzy graceful labelling. The mathematical concepts in *UV* wavelength have specific behavior according to its energy and frequency. In the context of the neutrosophic framework, the energy of a given wavelength indicates its membership within the neutrosophic set which encompasses three parts truth, indeterminacy and falsity. *UVC* (100–280 *nm*) as the most powerful and accurate wavelength range corresponds to the truth membership function. The energy and credibility to represent the truth of the neutrosophic perspective. *UVB* (280–315 *nm*) has moderate energy neither the least nor the most making it linked to the indeterminacy membership function *UVA* (315–400 *nm*) being the least energetic and longest wavelength, is associated with the false membership function. Its less intense and more spread-out effects signify less truth or a tilt towards falsehood in this arena. From this perspective, each wavelength is seen as a distinct individual with its own allotted amounts of truth, doubt, and falsehood in degrees. The very distinct energy bands their nature shows become domains which are obviously marked and allow for their differentiation within the neutrosophic model. This condition can be expressed mathematically as $T(UVC) > I(UVB) > F(UVA)$ and $T(UVC) \cap I(UVB) \cap (FUVA) = \emptyset$. The feature set of this non-colliding method confirms that the requirements of the neutrosophic fuzzy graceful label system are completely satisfied. Each wavelength of ultraviolet light is given its specific graceful label by the terms of this procedure, demonstrating the perfect balance and a well-defined relationship among the three components of neutrosophic theory. Thus, through these results, a connection was created between abstract mathematical concepts and the observed behaviours of optical phenomena. The creation of the neutrosophic grouping of ultraviolet light also presents a significant issue namely, that the way in which light manifests itself in Nature has both logical segments and segments that are fuzzy variable and are distinct from one another in nature. The basis for the converging of three distinct fields of study based fuzzy set theory, neutrosophic logic, and the physics of radiation. It facilitates our ability to understand how the variations in the Natural energy system may be classified and expressed through the use of graceful labels. Additionally, this supports the conclusion that mathematical reasoning can be used to express the vast range of order to complexity found in the natural world and is not limited to abstract theory. Furthermore, the containing of the ultraviolet spectrum by the geometry of a holographic image acts as a geometric confirmation of the neutrosophic framework described earlier. In the three-dimensional surface representation, the wavelength intervals corresponding to *UVC*, *UVB* and *UVA* are lifted from the planar partition into distinct intensity profiles, thereby translating the energy distribution of each band into a separable region in space. The holographic mapping makes explicit the non-overlapping domains of high, intermediate and low intensity can be encoded as the *T*, *I* and *F* components of a neutrosophic fuzzy graceful labeling, and thus offers a concrete optical realization of the underlying abstract structure. As such, the ultraviolet spectrum provides a tangible representation of how truth, indeterminacy, and falsity can be combined in a harmonious way within neutrosophic fuzzy graceful labeling, thus forming a bridge between mathematics, physics and philosophy.

7. Results

From a holographic standpoint, the *UV* induced increase in skin stiffness may be represented by encoding the displacement/strain response of the tissue into a three-dimensional phase or surface map, in which *UV* irradiated regions form sharper, higher amplitude features than non-exposed areas. Such a holographic visualization provides an intuitive mechanical contrast between normal and photodamaged skin, while preserving the quantitative information on stiffness and deformation behavior.

8. Conclusion

Ultraviolet rays are located between visible light and *X*-rays within the electromagnetic spectrum, covering wavelengths from 100 to 400 nanometers. People usually split this range into three sections, each with its own energy and effects on living things: *UVC* (100–280 nanometers), *UVB* (280–315 nanometers), and *UVA* (315–400 nanometers). Since each band acts so differently, it makes more sense to treat them as separate categories, not just lump them all together as *UV* radiation. All three types come from the Sun, but the ozone layer does most of the filtering. Almost all *UVC* and *UVB*, so by the time sunlight hits the ground, it's mostly *UVA*. Creating big doses of *UVC* or *UVB* happens like mercury vapor lamps, excimer lamps, or *UV* LEDs for that. These tools show up a lot in labs, hospitals, and places where disinfection is key. The different *UV* wavelengths as a hologram a kind of three-dimensional interference pattern get a sculpted *UV* landscape, where *UVC*, *UVB*, and *UVA* carve out their own regions. Some people even connect this idea to neutrosophy, mapping the three *UV* bands to concepts like truth, indeterminacy, and falsity. In physics, *UV* light and the logic behind those concepts start to blend together.

Authors' contributions

All authors have the same contribution.

Data Availability

The UV data used in this study were collected from the National Centers for Environmental Information.

Conflicts of Interest
The authors declare that they have no financial interests.

Ethical considerations
The authors declare no ethical consideration.

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