Applications of Interval-Valued Pythagorean Fuzzy Soft Graph in Bipolar Fuzzy Frame Works

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Abstract

The main contribution of this paper is to get extended ideas of various interval-valued bipolar Pythagorean fuzzy soft graphs (I-VBPFSGs) and to extend the concept of the Pythagorean fuzzy soft graph to the bipolar frameworks. Finally, in order to demonstrate, how to calculate an interval-valued Pythagorean bipolar fuzzy soft graph for a specific application, a numerical example using city data from the Yunnan province is presented.

Keywords: Pythagorean fuzzy soft graph; Bipolar fuzzy soft graph; Bipolar Pythagorean fuzzy soft graph; Interval-valued Pythagorean fuzzy soft graph; Interval-valued bipolar Pythagorean fuzzy soft graph.

2010 AMS subject classification: 05C72, 06D72, 12D15.

1. Introduction

Zadeh [19] introduced the idea of fuzzy sets to represent uncertainty or vague concepts by giving each element a membership degree that ranges from 0 to 1. Fuzzy set theory has been applied in a variety of fields, since Zadeh's innovative work, including management sciences, engineering, mathematics, social sciences, statistics, signal processing, artificial intelligence, automata theory, and the medical and biological sciences. By Atanassov [5], the concept of fuzzy sets was expanded and developed to a brand-new set theory known as "intuitionistic fuzzy sets." Each element in the intuitionistic fuzzy set has degrees of membership and non-membership, with values that range from 0 to 1. In the past three decades, intuitionistic fuzzy set theory has received a lot of attention, and a variety of applications in fields including decision-making, clustering analysis, pattern recognition, and medical diagnosis have been developed. Graph theory is an important branch of applied mathematics and has numerous fields, including computer science, economics, social sciences, chemistry, physics, system analysis, neural networks, electrical engineering, control theory, transportation, architecture, and communication. To deal with these kinds of circumstances, Rosenfeld [13] expanded Euler's graph theory and demonstrated the fundamental findings on fuzzy graphs (FGs). Bhattacharya [7] made some comments on FGs and established some connectivity concepts regarding fuzzy cut nodes and fuzzy brides. Akram and Davvaz [2] studied the strong interval-valued fuzzy graphs. Furthermore, Akram and Dudek [3] introduced intuitionistic fuzzy hypergraphs and talked about possible uses for them. Yager [16-17] has proposed the Pythagorean fuzzy set (PFS) as an effective tool for handling the uncertainty or vague information more adequately in real-world situations. In PFSs, the sum of square of the degrees of membership and non-membership is less than or equal to 1. For instance, if a decision-maker includes the membership degree of 0.7 and the non-membership degree of 0.8 in his analysis, intuitionistic fuzzy set theory cannot handle this circumstance because 0.7+ 0.8 > 1. To illustrate that the Pythagorean fuzzy set (PFS) is able to represent this evaluation information, it is simple to see that$(0.7)^2 + (0.8)^2 < 1$. In other words, the PFSs are more capable of handling issues in uncertain circumstances. Many researchers have begun their study in various directions under the PFS setting and

Doi: https://doi.org/10.54216/JNFS.070204
Received: May 17, 2023 Revised: September 12, 2023 Accepted: November 19, 2023

have produced a variety of significant results. the relation between Pythagorean membership degrees and complex numbers was demonstrated along with the demonstration that Pythagorean degrees are a subclass of complex numbers. Zhang and Xu [20] presented the mathematical from of the Pythagorean fuzzy set and introduced the concept of the Pythagorean fuzzy number (PFN). Akram and Dudek [1] introduced the IVFS theory as a continuation of fuzzy sets. Because they offer a better explanation of uncertainty than standard fuzzy sets, interval-valued fuzzy sets are more useful. Atanassov and Gargov [6] studied by interval-valued intuitionistic fuzzy sets (IVIFS). Yahya Mohamed and Mohamed Ali [12] introduced the concept of interval-valued Pythagorean fuzzy graph. Molodstov [9] developed soft set theory as a parameterized perspective for soft computing and uncertainty modelling. Shahzadi and Akram [14] introduced the IFGs. IFSGs are different types of new concepts, including complete intuitionistic fuzzy soft graphs, Strong intuitionistic fuzzy soft graphs and self-complement of intuitionistic fuzzy soft graphs. Akram and Shahzadi [4] introduced by Pythagorean fuzzy soft graphs with applications. Sivasamy et al. [15] studied by I-VPFSGs. Mohammed Jabarulla and Sivasamy [11] studied by strong interval-valued Pythagorean fuzzy soft graphs is different types of operations, including cartesian product, composition, union of Pythagorean fuzzy soft graphs. According to Zhang [21] the bipolar fuzzy sets have an explanation. Zhang increased the size of the fuzzy sets by making them bipolar fuzzy sets by adding the membership value in the [-1,1] range. In a bipolar fuzzy set, if an element has a membership degree of 0, it is irrelevant to the corresponding property; if it has a membership degree of [0,1], it partially satisfies the property; and if it has a membership degree of [-1,0], it partially satisfies the implicit counter property. The theoretical framework developed by Mishra and Pal [10] to characterise the relational behaviour of objects with an interval-valued membership is increased in significance. This paper mainly contributes to extend the concept of the Pythagorean fuzzy soft graph to the bipolar frame works and obtain the related expanded concepts of variety of interval-valued Pythagorean bipolar fuzzy soft graphs. Finally, a numerical example on city data in Yunnan province is presented to explain the computing of interval-valued bipolar Pythagorean fuzzy soft graph in the specific applications.

2. Preliminaries

Definition 2.1 An I-VPFSG over a set V is given by $\tilde{\mathcal{G}} = (\tilde{\mathcal{G}}^*, X, Y, \delta)$ such that

i. δ is a non-empty set of parameters,
ii. (X, δ) is an I-VPFSS over V,
iii. (Y, δ) is an I-VPFSS over E,
iv. $(X(e), Y(e))$ is an I-VPFSG for all $e \in \delta$.

$\alpha_{YL}((x,y)) \leq \min(\alpha_{XL}(x), \alpha_{XL}(y))$ and
$\beta_{YL}((x,y)) \geq \max\big(\beta_{XL}(x), \beta_{XL}(y)\big)$,
$\alpha_{YU}((x,y)) \leq \min(\alpha_{XU}(x), \alpha_{XU}(y))$ and
$\beta_{YU}((x,y)) \geq \max\big(\beta_{XU}(x), \beta_{XU}(y)\big)$,
$0 \leq (\alpha_{YU}(x,y)^2 + (\beta_{YU}(x,y)^2 \ \forall\ (x,y) \in E.$

Definition 2.2. An SI-VPFSG over a set V is given by ordered 4 tuples $\tilde{\mathcal{G}} = (\mathcal{G}^*, X, Y, \delta)$ such that

i. δ is a non-empty set of parameters,
ii. (X, δ) is an SIVPFSS over V,
iii. (Y, δ) is an SIVPFSS over E,
iv. $(X(e), Y(e))$ is an SIVPFSG $\forall\ e \in \delta$.

$\alpha_{YL}((x,y)) = (\alpha_{XL}(x) \wedge \alpha_{XL}(y))$ and
$\beta_{YL}\big((x,y)\big) = \big(\beta_{XL}(x) \vee \beta_{XL}(y)\big)$,
$\alpha_{YU}((x,y)) = (\alpha_{XU}(x) \wedge \alpha_{XU}(y))$ and
$\beta_{YU}\big((x,y)\big) = \big(\beta_{XU}(x) \vee \beta_{XU}(y)\big)$,
$0 \leq (\alpha_{YU}(x,y)^2 + (\beta_{YU}(x,y)^2 \leq 1 \ \forall\ (x,y) \in E.$

3. Interval-valued bipolar Pythagorean fuzzy soft graph

Definition 3.1 A BPFSG on a non-empty set V is an ordered 4-tuble $\tilde{\mathcal{G}} = \big(\tilde{\mathcal{G}}^*, X, Y, \delta\big)$ such that

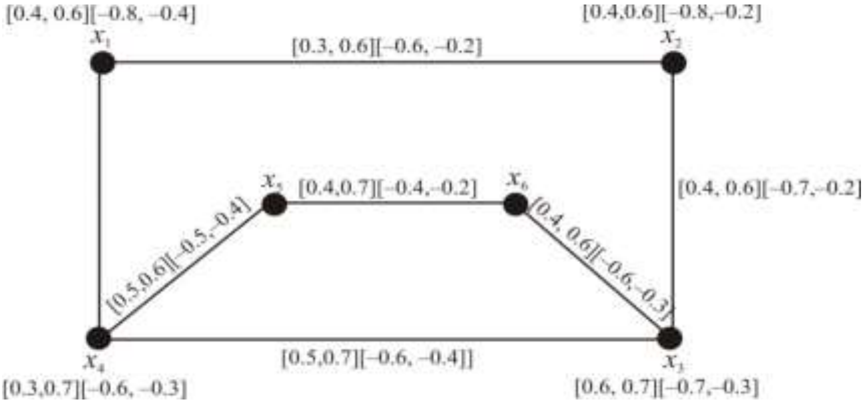
$i.$ δ is a non-empty set of parameters,
$ii.$ (X, δ) is an BPFSS over V,
$iii.$ (Y, δ) is an BPFSS over$E$,
$iv.$ $(X(e), Y(e))$is an BPFSG for all $e \in \delta$.

Here $X = (\alpha_X^+, \beta_X^+, \alpha_X^-, \beta_X^-)$ is a Pythagorean fuzzy soft set on V and $Y = (\alpha_Y^+, \beta_Y^+, \alpha_Y^-, \beta_Y^-)$ is a BPFSS on $E \subseteq V \times V$ such that

$\alpha_Y^+(xy) \leq min(\alpha_X^+(x), (\alpha_X^+(y))$,
$\beta_Y^+(xy) \geq max(\beta_X^+(x), (\beta_X^+(y))$,
$\alpha_Y^-(xy) \geq max(\alpha_X^-(x), (\alpha_X^-(y))$,
$\beta_Y^-(xy) \leq min(\beta_X^-(x), (\beta_X^-(y))$ for all $(xy) \in E$, such that
$0 \leq (\alpha_X^+(xy))^2 + (\beta_X^+(xy))^2 \leq 1$ and $-1 \leq -[(\alpha_X^-(xy))^2 + (\beta_X^-(xy))^2] \leq 0.$

Doi: https://doi.org/10.54216/JNFS.070204
Received: May 17, 2023 Revised: September 12, 2023 Accepted: November 19, 2023

Example 3.2. Let a graph $\tilde{\mathcal{G}}^{*}$= (X,Y) be a simple graph with $X=\{x_1,x_2,x_3,x_4,x_5,x_6\}$ and $Y=\{x_1x_2,x_1x_4,x_2x_3,x_3x_4,,x_3x_6,x_4x_5,x_5x_6\}$. Let $H=\{e\}$ be a parameter set and (X,δ) be a BPFS set V defined by $X(e)$. Now let (Y,δ) be a BPFS set E defined by $Y(e)$. It is clearly seen that $H(e)=(X(e),Y(e)$ is an I-VBPFSG in relation to the parameters e consequently, as shown Figure1. Hence $\tilde{\mathcal{G}}=(\mathcal{G}^{*},X,Y,\delta)$ is I-VBPFSG.



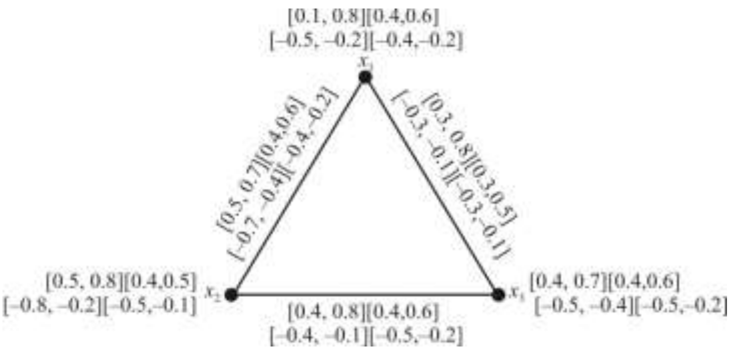
$H(e)$ corresponding to the parameter e

Figure 1: Bipolar Pythagorean fuzzy soft graph

Definition 3.3 An interval-valued bipolar Pythagorean fuzzy soft graph with an underlying set V is a 4-tuble $\tilde{\mathcal{G}}=(\tilde{\mathcal{G}}^{*},X,Y,\delta)$ such that
$i.$ δ is a non - empty set of parameters,
$ii.$ (X,δ) is an I-VBPFSS over V,
$iii.$ (Y,δ) is an I-VBPFSS over $E\subseteq V\times V$,
$iv.$ $(X(e),Y(e))$ is an I-VBPFSG for all $e\in\delta$.
That is,
$\alpha^{+}_{YL}(xy)\le min(\alpha^{+}_{XL}(x),(\alpha^{+}_{XL}(y))$
$\beta^{+}_{YL}(xy)\ge max(\beta^{+}_{XL}(x),(\beta^{+}_{XL}(y)),$
$\alpha^{+}_{YU}(xy)\le min(\alpha^{+}_{XU}(x),(\alpha^{+}_{XU}(y))$
$\beta^{+}_{YU}(xy)\ge max(\beta^{+}_{XU}(x),(\beta^{+}_{XU}(y))$ and
$\alpha^{-}_{YL}(xy)\ge max(\alpha^{-}_{XL}(x),(\alpha^{-}_{XL}(y))$
$\beta^{-}_{YL}(xy)\le min(\beta^{-}_{XL}(x),(\beta^{-}_{XL}(y))$
$\alpha^{-}_{YU}(xy)\ge max(\alpha^{-}_{XU}(x),(\alpha^{-}_{XU}(y)),$
$\beta^{-}_{YU}(xy)\le min(\beta^{-}_{XU}(x),(\beta^{-}_{XU}(y))$ for all $(xy)\in E$,
such that $0\le(\alpha^{+}_{YU}(xy))^2+(\beta^{+}_{YU}(xy))^2\le 1$ and$-1\le-[(\alpha^{-}_{YU}(xy))^2+(\beta^{-}_{YU}(xy))^2]\le 0$.

Definition 3.4 An I-VBPFSG $\mathcal{G}$ is said to be (k_1,k_2)- regular I-VBPFSG if degree of each vertex remains constant (k_1,k_2) for all $v\in\tilde{\mathcal{G}}$ where k_1 and k_2 are real numbers and $k_1=d^{P}(x)$ and $k_2=d^{N}(x),\forall\, x\in V$.

Example 3.5 Let $\tilde{\mathcal{G}}$ be an I-VBPFSG underlying $\tilde{\mathcal{G}}^{*}=(V,E)$ and $V=\{x_1,x_2,x_3\}$ and $E=\{x_1x_2,x_2x_3,x_1x_3\}$.



$H(e)$ corresponding to the parameter e

Figure 2: Interval – valued bipolar Pythagorean fuzzy soft graph

Figure 2 follows the degrees of x_1,x_2,x_3 as

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$$\begin{aligned}\left(d^P(x_1), d^N(x_1)\right) &= \begin{pmatrix}\left((0.7+0.8+0.8)-(0.6+0.6+0.5)\right), ((-0.4-0.2-0.1)\\ (-0.2-0.2-0.1))\end{pmatrix}\\ &= \left((2.3-1.7), (-0.7-0.5)\right)\\ &= (0.6, -1.2),\\ \left(d^P(x_2), d^N(x_2)\right) &= \begin{pmatrix}\left((0.8+0.7+0.8)-(0.5+0.6+0.6)\right), ((-0.2-0.4-0.1)\\ (-0.1-0.2-0.2))\end{pmatrix}\\ &= ((2.3-1.7), (-0.7-0.5))\\ &= (0.6, -1.2).\end{aligned}$$

Similarly, we obtain

$\left(d^P(x_3), d^N(x_3)\right) = (0.6, -1.2)$.

Since the degree of all vertices are equal, $\tilde{\mathcal{G}}$ is $(0.6, -0.2)$ regular IVBPFG.

Theorem. 3.6 A interval-valued bipolar Pythagorean fuzzy soft graph $\tilde{\mathcal{G}}$ is regular if all the vertices of $\mathcal{G}^*$ induced from $\tilde{\mathcal{G}}$ have same degree and $\psi_{BL} + \psi_{BU}, \Delta_{BL} + \Delta_{BU}$ are constant for $x, y \in B$.

Proof: As we know I-VBPFSG $\tilde{\mathcal{G}}$ is regular if all vertices have constant degrees, (k_1, k_2) where $k_1 = \sum_{x\neq y, xy\in B} \frac{\psi_{BL}(xy)+\psi_{BU}(xy)}{2}$ *and* $k_2 = \sum_{x\neq y, xy\in B} \frac{\Delta_{BL}(xy)+\Delta_{BU}(xy)}{2}$. Therefore, the degrees of each vertex in $\tilde{\mathcal{G}}$ depends only on the degree of the vertices of the underlying graph $\tilde{\mathcal{G}}$ if the sum of the lower and upper limits of the satisfaction degree of interval and the satisfaction degrees of interval to some of the implicit counter property remains constant for all edges of $\tilde{\mathcal{G}}$. As a result, $\tilde{\mathcal{G}}^*$ is a set of constant degrees for each node if the degrees of all $\tilde{\mathcal{G}}$ vertices likewise become a constant.

Theorem.3.7 An interval-valued bipolar Pythagorean fuzzy soft cycle is regular then for any $xy \in B$ have at most $max\left(\left[\frac{k_1}{2}\right]\left[\frac{k_2}{2}\right]\right)$ number of distinct satisfaction degree of interval or the satisfaction degree of interval to some implicate counter property assuming k_1 and k_2 as the positive integer.

Proof: Let $\widetilde{A_n}$ be an I-VBPFS cycle underlying $A_{n.}$ Suppose t_1 and t_2 are the sums of the lower and upper limit of γ_B and Δ_B of $\widetilde{A_n}$ for each edge. Thus, for regular $\widetilde{A_n}$, $t_1$and t_2 have to be same for all edges. We know that, $k_1 = \sum_{xy\in B} \frac{t_1}{2}$ and $k_2 = \sum_{xy\in B} \frac{t_2}{2}$.thus constant k_1 and k_2 is only possible where the satisfaction degree of interval and the satisfaction degree of interval to some implicit counter properties are made up from bipartition of k_1 and k_2. the partition of k_1 and k_2 are $\left[\frac{k_1}{2}\right]$ and $\left[\frac{k_2}{2}\right]$ respectively if k_1 and k_2 are positive integers. As in the problem k_1, k_2 are always float so, we have to the decimal for the bipartition of k_1 and k_2. Now the distinct interval for any number is equal to the number possible bipartition. Thus, the number of distinct pair of the interval for two numbers are almost maximum of bipartition of that two numbers.

For example:

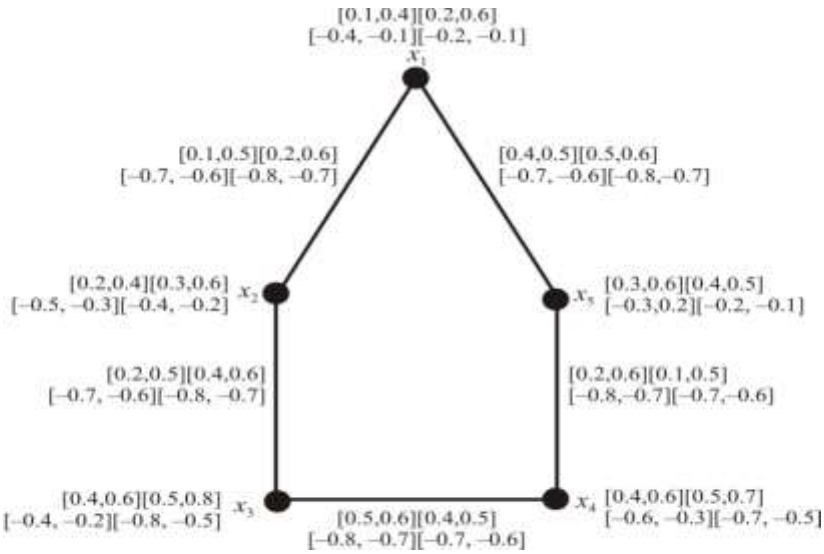

Figure 3: Interval – valued bipolar Pythagorean fuzzy soft graph

$\max\left\{\left[\frac{11}{2}\right], \left[\frac{13}{2}\right]\right\} = 6.$

Doi: https://doi.org/10.54216/JNFS.070204
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Hence the maximum length for the cycle is 5 for distinct positive membership interval.

4. Applications of interval-valued bipolar Pythagorean fuzzy soft graph (AI-VBPFSG)

A numerical experiment Yunnan province is one of the provinces with frequent earthquakes in China. There are two well-known geological plate fault zones “Indonesia Fault Zone:” and “Taiwan Fault Zone” located in Yunnan Province. This has caused areas along the fault zone to become a high-risk area for earthquakes, such as “X”, To “X”, “Y”, “Z” and so on. In recent 5 years, earthquakes above 5-level scale that occurred in Yunnan are shown in Table 1. Therefore, the Yunnan provincial natural resources Bureau established the Emergency Disaster Department, Fig. 1 which specializes in the emergency management of natural disasters including earthquake relief. Now, suppose we need to choose several cities from Yunnan Province to build earthquake resistant warehouses that can store food, machinery and sanitary materials, and can use land transportation. Fast transportation between cities in the event of an earthquake above the scale becomes essential in the earthquake rescue and relief.

Table 1: Earthquakes of magnitude 5 and above in Yunnan Province in the past 5 years

Date	Location	Earth Quake Level
February 2004	Indonesia	6.1
August 2005	China	5.9
April 2006	Pakistan	5.8
September 2007	Taiwan	6.3
July 2008	France	5.2

To convey the uncertainty and distort the graph, we must employ an interval-valued bipolar Pythagorean fuzzy membership and non-membership function. These uncertainties include the distance between cities, quality, safety, obstacles on the route, and traffic while building emergency warehouses. There are differences between and other factors. The city takes into account various urban agglomerations for cost-saving reasons. The entire province of Yunnan can be split into six significant urban agglomerations, according to the overall national plan: Central Yunnan, Northeast Yunnan, Southwest Yunnan, West Yunnan, Northwest Yunnan, and Southeast Yunnan. These six urban agglomerations must be taken into consideration when selecting cities.

We ask an expected graph to assign a pair of values in the intervals based on the figure 4.$[0,1] \times [-1,0]$ to each city to score the city.

For each of the items mentioned above, there is a function from V: $[0,1] \times [-1,0]$, denoted as

$S_1 = [S_1^+, S_1^-]$, $S_2 = [S_2^+, S_2^-]$, $S_3 = [S_3^+, S_3^-]$, $S_4 = [S_4^+, S_4^-]$ respectively.

Consider the I-VBPF membership function $\alpha_{DL}^+, \alpha_{DU}^+, \alpha_{DL}^-, \alpha_{DU}^-$ on Vas the average scores. We assigned a weighted coefficient of 0.3, 0.2, 0.3, and 0.2 to each item. Therefore, for any $\psi \in V$, We compute the positive (+) and negative (-) score values using the weighting technique shown below.

$\alpha_{DL}^+ = 0.3S_1^+ + 0.2S_2^+ + 0.3S_3^+ + 0.2S_4^+$,
$\alpha_{DU}^+ = 0.3S_1^+ + 0.2S_2^+ + 0.3S_3^+ + 0.2S_4^+$,
$\alpha_{DL}^- = 0.3S_1^- + 0.2S_2^- + 0.3S_3^- + 0.2S_4^-$,
$\alpha_{DU}^- = 0.3S_1^- + 0.2S_2^- + 0.3S_3^- + 0.2S_4^-$.

To assess if a route connecting two cities belongs to the IVBPSF, the following factors are taken into account for each edge.

1. The length of Road
2. Road Condition.

For any $xy \in E$ suppose

$Y_L^+(xy) = min\{e^+(xy), e^+(x), e^+(y)\}$,
$Y_U^+(xy) = min\{e^+(xy), e^+(x), e^+(y)\}$and
$Y_L^-(xy) = max\{e^-(xy), e^-(x), e^-(y)\}$,
$Y_U^-(xy) = max\{e^-(xy), e^-(x), e^-(y)\}$.

Since

$Y_L^+(xy) \leq \{\alpha_{XL}^+(x), \alpha_{XL}^+(y)\}$,
$Y_U^+(xy) \leq \{\alpha_{XU}^+(x), \alpha_{XU}^+(y)\}$and
$Y_L^-(xy) \geq \{\alpha_{XL}^-(x), \alpha_{DL}^-(y)\}$,
$Y_U^-(xy) \geq \{\alpha_{XU}^-(x), \alpha_{XU}^-(y)\}$.

It complies with the structure established by the organization's membership and non-membership functions. In vertices $x_{1,} x_{2,} \ldots . x_5$ and edges of Interval-valued Pythagorean fuzzy soft graph.

Doi: https://doi.org/10.54216/JNFS.070204
Received: May 17, 2023 Revised: September 12, 2023 Accepted: November 19, 2023

Table 2: Score of each city

Vertex	$[S_1^+, S_1^-]$	$[S_2^+, S_2^-]$	$[S_3^+, S_3^-]$	$[S_4^+, S_4^-]$	Score function value
x_1	[0.2,0.6] [0.3,0.5] [-0.7, -0.3] [-0.6, -0.2]	[0.3,0.6] [0.4,0.8] [-0.8, -0.2] [-0.6, -0.1]	[0.2,0.4] [0.3,0.6] [-0.4, -0.2] [-0.3, -0.2]	[0.4,0.6] [0.3,0.8] [-0.3, -0.1] [-0.4, -0.2]	[0.2,0.5] [0.3,0.6] [-0.5, -0.2] [-0.4, -0.1]
x_2	0.3,0.8] [0.4,0.6] [-0.7, -0.4] [-0.8, -0.2]	[0.4,0.8] [0.2,0.6] [-0.4, -0.3] [-0.3, -0.2]	[0.3,0.6] [0.4,0.8] [-0.4, -0.2] [-0.2, -0.1]	[0.7,0.8] [0.4,0.5] [-0.4, -0.2] [-0.4,-0.1]	[0.4,0.7] [0.3,0.6] [-0.4, -0.3] [-0.3,-0.1]
x_3	[0.2,0.7] [0.4,0.8] [-0.5, -0.2] [-0.6, -0.4]	[0.2,0.7] [0.3,0.4] [-0.3, -0.2] [-0.2, -0.1]	[0.2,0.6] [0.3,0.8] [-0.3, -0.1] [-0.2, -0.1]	[0.6,0.7] [0.4,0.8] [-0.4, -0.2] [-0.2, -0.1]	[0.3,0.6] [0.3,0.7] [-0.3, -0.2] [-0.3, -0.2]
x_4	[0.3,0.6] [0.2,0.8] [-0.4, -0.2] [-0.5, -0.3]	[0.4,0.6] [0.3,0.8] [-0.3, -0.1] [-0.4, -0.1]	[0.3,0.6] [0.3,0.7] [-0.4, -0.2] [-0.3, -0.1]	[0.4,0.6] [0.3,0.7] [-0.3, -0.1] [-0.2, -0.1]	[0.3,0.6] [0.2,0.7] [-0.3, -0.1] [-0.3, -0.1]
x_5	[0.4,0.6] [0.2,0.8] [-0.4, -0.2] [-0.5, -0.3]	[0.2,0.5] [0.3,0.6] [-0.2, -0.1] [-0.3, -0.1]	[0.4,0.6] [0.6,0.8] [-0.3, -0.2] [-0.2, -0.1]	[0.3,0.7] [0.2,0.6] [-0.3, -0.2] [-0.2, -0.1]	[0.3,0.6] [0.3,0.7] [-0.4, -0.2] [-0.3, -0.1]

All of the edges shown above are legitimate edges of $G = (V, \alpha_D^+(x), \alpha_D^-(y), Y^+, Y^-)$. Assign the following table if a city meets the criteria needed to construct an earthquake-resistant warehouse and is able to travel to another city via roadways.

Table 3: Calculation of edge membership and non-membership function of I-VBPFSG.

Edge	$[e_1^+, e_1^-]$	$[e_2^+, e_2^-]$	$[e^+, e^-]$	$[Y^+, Y^-]$
x_1x_2	[0.3,0.5] [0.4,0.6] [-0.4, -0.2] [-0.6, -0.4]	[0.5,0.6] [0.3,0.7] [-0.3, -0.2] [-0.3, -0.2]	[0.4,0.5] [0.3,0.6] [-0.3, -0.2] [-0.4, -0.3]	[0.2,0.5] [0.3,0.6] [-0.3, -0.2] [-0.3, -0.1]
x_2x_3	[0.2,0.4] [0.5,0.6] [-0.3, -0.1] [-0.2, -0.1]	[0.4,0.6] [0.3,0.5] [-0.4, -0.2] [-0.3, -0.1]	[0.3,0.5] [0.4,0.6] [-0.3, -0.1] [-0.2, -0.1]	[0.3,0.5] [0.3,0.6] [-0.3, -0.1] [-0.2, -0.1]
x_5x_1	[0.3,0.4] [0.5,0.6] [-0.4, -0.2] [-0.3, -0.2]	[0.3,0.6] [0.4,0.5] [-0.3, -0.1] [-0.2, -0.1]	[0.3,0.5] [0.4,0.6] [-0.3, -0.1] [-0.2, -0.1]	[0.3,0.5] [0.3,0.6] [-0.3, -0.1] [-0.2, -0.1]
x_3x_4	[0.4,0.6] [0.3,0.5] [-0.5, -0.3] [-0.2, -0.1]	[0.4,0.5] [0.3,0.6] [-0.3, -0.2] [-0.2, -0.1]	[0.4,0.5] [0.3,0.5] [-0.4, -0.2] [-0.2, -0.1]	[0.3,0.5] [0.2,0.5] [-0.3, -0.1] [-0.2, -0.1]
x_4x_5	[0.4,0.6] [0.3,0.4] [-0.4, -0.2] [-0.4, -0.1]	[0.6,0.7] [0.4,0.6] [-0.3, -0.1] [-0.4, -0.2]	[0.5,0.6] [0.3,0.5] [-0.3, -0.1] [-0.4, -0.1]	[0.3,0.6] [0.3,0.5] [-0.3, -0.1] [-0.3, -0.1]

Moreover $G = (V, \alpha_{DL}^+(x), \alpha_{DU}^+(y)\ \alpha_{DL}^-(x), \alpha_{DU}^-(y), Y^+, Y^-)$is an IVBPFSG, by calculating, it can be shown that other values of edges.

Doi: https://doi.org/10.54216/JNFS.070204
Received: May 17, 2023 Revised: September 12, 2023 Accepted: November 19, 2023

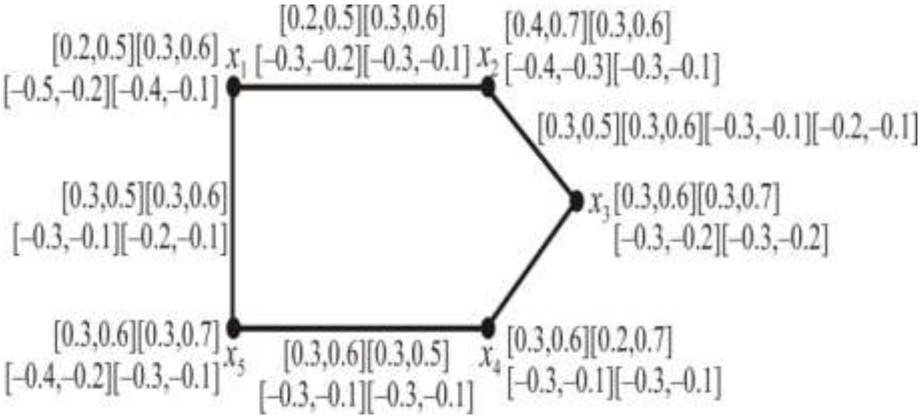

Figure 4: I-VBPFSG.

Finally, we use come to conclusion, The calculation results can be achieved using the techniques described in this work using the example of an earthquake-resistant warehouse in Yunnan province. For this specific application, we think this choice is appropriate.

While it may appear logical to choose Yunnan Province given its capacity, the fact it is situated in a fault zone makes it unsuitable for mathematical storage.

The cities of X, Y, and Z in the province of Yunnan should be created, according to the calculations we provided. If score function maximum value of x_4, x_5 and corresponding to edges x_3x_4 and x_4x_5.

5. Conclusion

Pythagorean fuzzy graphs theory plays a significant role in modelling many real-world problems containing uncertainties in different fields such as decision-making theory, computer science, optimization problems, data analysis, networking etc. In this perspective, a number of generalizations of interval valued bipolar Pythagorean fuzzy soft graph have been introduced to deal with the difficult and complex real-life problems. Bipolar Pythagorean fuzzy soft graph is another generalized form of Pythagorean fuzzy soft graph which is also an effective tool for the multivalent decision analysis.

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Doi: https://doi.org/10.54216/JNFS.070204
Received: May 17, 2023 Revised: September 12, 2023 Accepted: November 19, 2023