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Application of $m-$ polar soft fuzzy bi-partite graph in residence selection process

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Abstract

An $m-$ polar fuzzy set and soft sets are two different tools for representing uncertainty and vagueness. An $m-$ polar soft fuzzy set is a mapping from parameter set to the $m-$ polar fuzzy subsets of universe. An $m-$ polar soft fuzzy set theory provides a parameterized point of view for uncertainty modeling and soft computing model. In this paper, we have introduced the notions of $m-$ polar soft fuzzy bipartite graph, size and degree of $m-$ polar soft fuzzy bi-partite graph as well as an investigation on buying of residence by considering various parameter. People while buying residence have many options. So, to choose the best one, they have to consider many parameters. $m-$ polar soft fuzzy graph is one of the major area of graph theory, which finds solution to this problem.

Keywords: $m-$ polar soft fuzzy bi-partite graph, $m-$ polar soft fuzzy graph, size of $m-$ polar soft fuzzy bi-partite graph.
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1 Introduction

Ali et al. [2011] conducted a study on soft sets stimulation of the fuzzy sets and fuzzy soft sets. In 2014, Juanjuan Chen [2014] defined the $m-$ polar fuzzy graphs. Mathew Varkey and T. K. Shyla [2017] introduced bipartite and balanced fuzzy graph structures. The concept of fuzzy soft graph was presented by Mohinta Sumit and T. K. Samanta [2015]. D. A Molodtsov [1997] initiated the notion of the soft set theory. M. Akram and S. Nawaz [2016] presented new ideas known as fuzzy soft graphs with applications. A. Rosenfeld et al. [1975] developed the concept of fuzzy graphs in fuzzy sets and their applications. S. Ramkumar and R. Sridevi [2021] introduced their perception on proper $m-$ polar soft fuzzy graphs. S. Ramkumar and R. Sridevi [2023] presented some applications of Min-Max $m-$ polar soft fuzzy graphs in decision making. In S. Ramkumar and R. Sridevi [2023] introduced on improper $m-$polar soft fuzzy graph and it's applications for medical diagnosis in the current COVID-19 scenario. An $m-$ polar soft fuzzy graph is a useful mathematical tool for simulating the ambiguity of the real world. The $m-$ polar soft fuzzy set and the graph model are combined to create the commonly used $m-$ polar soft fuzzy graph. The newly integrated ideas of the soft sets and $m-$ polar fuzzy sets will lead to numerous prospective applications in the $m-$ polar soft fuzzy set theoretical domain by adding extra fuzziness in analysing, as an $m-$polar soft fuzzy sets are the most useful in practical applications. The current paper proposes the application of $m-$ polar soft fuzzy bi-partite graphs in residence selection process. This topic focuses on this problem so that we are able to choose the best one. In normal fuzzy set or crisp set, We can consider just one parameter. By considering one parameter, it is somewhat difficult to choose the best one. But in $m-$ polar soft fuzzy set, we are able to apply various facilities required as per the wish. To solve this problem, we consider $m-$ polar soft fuzzy bipartite graph with first bi-partition having exclusive amenities close to each type of residence and second bi-partition having exclusive in-built amenities of each type of residence. Here, the parameter represents specific condition near by residence in addition to the above conditions. We have considered the application for $m = 3$ attributes.

2 Preliminaries

Definition 2.1. *An m $-polar$ soft fuzzy graph $\widetilde{G}_{P,V} = (G^*, \widetilde{\rho}, \widetilde{\mu}, P)$ is a 4 $-$tuple such that*

(a) $G^* = (V, E)$ is a simple graph,

(b) P *is a nonempty set of parameters,*

(c) $\widetilde{\rho} : P \to F(V)\,(collection\ of\ all\ m-polar fuzzy\ subsets\ in\ V)$

$$\mathfrak{e} \to \widetilde{\rho}(\mathfrak{e}) = \widetilde{\rho}_{\mathfrak{e}}(say)$$

and $\widetilde{\rho}_{\mathfrak{e}} : V \to [0,1]^m$

$$(x_1, x_2, \ldots, x_m) \mapsto \widetilde{\rho}_{\mathfrak{e}}\,(x_1, x_2, \ldots, x_m)$$

$(\widetilde{\rho}, P)$ *is an* m *−polar soft fuzzy set over* V

(d) $\widetilde{\mu} : P \to F\,(V \times V)\,(collection\ of\ all\ m-polar fuzzy\ subsets\ in\ V \times V)$

$$\mathfrak{e} \mapsto \widetilde{\mu}\,(\mathfrak{e}) = \widetilde{\mu}_{\mathfrak{e}}\,(say)$$

and $\widetilde{\mu}_{\mathfrak{e}} : V \times V \to [0,1]^m$

$$(x_1, x_2, \ldots, x_m) \mapsto \widetilde{\mu}_{\mathfrak{e}}\,(x_1, x_2, \ldots, x_m)$$

$(\widetilde{\mu}, P)$ *is an* m *−polar soft fuzzy set over* E

(e) $(\widetilde{\rho}_e, \widetilde{\mu}_e)$ *is an* m *−polar fuzzy subgraph of* G^* *for all* $e \in P$*. That is,*

$$\begin{gathered}
\widetilde{\mu}_e x_1(uv) \leq (\widetilde{\rho}_e x_1(u) \wedge \widetilde{\rho}_e x_1(v)) \\
\widetilde{\mu}_e x_2(uv) \leq (\widetilde{\rho}_e x_2(u) \wedge \widetilde{\rho}_e x_2(v)) \\
\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \\
\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \\
\widetilde{\mu}_e x_m(uv) \leq (\widetilde{\rho}_e x_m(u) \wedge \widetilde{\rho}_e x_m(v))
\end{gathered}$$

for all $e \in P$ *and* $u, v \in V$*. The* m *−polar fuzzy graph* $(\widetilde{\rho}_e, \widetilde{\mu}_e)$ *is denoted by* $\widetilde{H}_{P,V}(e)$ *for convenience.*

Definition 2.2. *A fuzzy graph* $G = (\mu, \rho)$ *is said to be a fuzzy Bi-partite graph. if the vertex set* V *is partitioned into two disjoint union of two vertex sets* V_1 *and* V_2 *such that for all* $x, y \in V_1$ *or for all* $x, y \in V_2$ *,* $\rho(x, y) = \frac{1}{2}[\mu(x) \wedge \mu(y)]$*. This fuzzy Bi-partite graph can be denoted by* $G(V_1, V_2, \mu, \rho)$*.*

3 $m-$ polar soft fuzzy bi-partite graph

Definition 3.1. *An* $m-$ *polar soft fuzzy graph* $\widetilde{G}_{P,V} = (G^*, \widetilde{\rho}, \widetilde{\mu}, P)$ *is said to be an* $m-$*polar soft fuzzy bi-partite graph if the vertex set* V *is partitioned into two disjoint vertex pair* V_1 *and* V_2

$$\begin{gathered}
\widetilde{\mu}_e x_1(uv) \leq (\widetilde{\rho}_e x_1(u) \wedge \widetilde{\rho}_e x_1(v)) \\
\widetilde{\mu}_e x_2(uv) \leq (\widetilde{\rho}_e x_2(u) \wedge \widetilde{\rho}_e x_2(v)) \\
\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \\
\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \\
\widetilde{\mu}_e x_m(uv) \leq (\widetilde{\rho}_e x_m(u) \wedge \widetilde{\rho}_e x_m(v))
\end{gathered}$$

in $\widetilde{H}_{P,V}(e)$ $\forall e \in P$ *and for all* $u \in V_1, v \in V_2$.

Definition 3.2. *The Size of an* $m-$*polar soft fuzzy bi-partite graph is defined as* $S(\widetilde{G}_{P,V_1 \cup V_2}) = \sum_{e \in P} \sum_{(x_1,x_2,\ldots,x_m)uv \in V_1 \cup V_2} \widetilde{\mu}_e(x_1, x_2, \ldots, x_m)(uv)$.

Example 3.1. *Consider a* $3-$ *polar soft fuzzy graph* $\widetilde{G}_{P,V}$, *where* $V = V_1 \cup V_2 = \{a_1, a_2, a_3, b_1, b_2, b_3\}$ *and* $P = \{e_1, e_2\}$ *and* $E = \{a_1b_1, a_1b_2, a_2b_1, a_1b_3,$ $a_2b_2, a_2b_3, a_3b_3\}$.

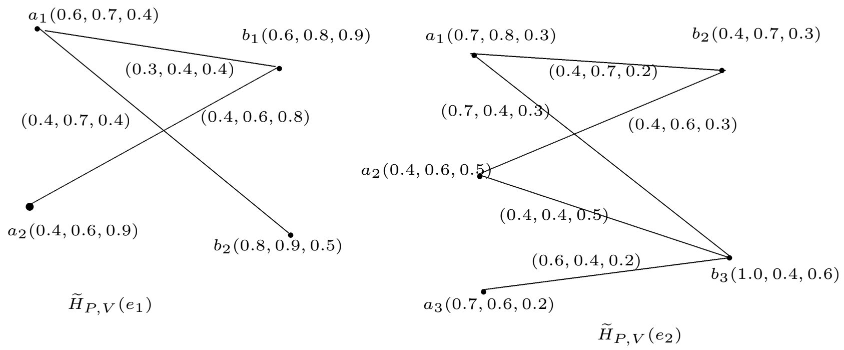

Figure 1: $3-$polar fuzzy bi-partite graph

In Figure 1. The size of $3-$polar fuzzy bi-partite graph $\widetilde{H}_{P,V}(e)$ is
$S(\widetilde{H}_{P,V}(e_1)) = \sum_{(x_1,x_2,x_3)ab \in V_1 \cup V_2} \widetilde{\mu}_e(x_1, x_2, x_3)(ab) = (1.1, 1.7, 1.6)$,
$S(\widetilde{H}_{P,V}(e_2)) = \sum_{(x_1,x_2,x_3)ab \in V_1 \cup V_2} \widetilde{\mu}_e(x_1, x_2, x_3)(ab) = (2.5, 2.5, 1.5)$.

The size of $3-$polar soft fuzzy bi-partite graph $\widetilde{G}_{P,V}$ is
$S(\widetilde{G}_{P,V_1 \cup V_2}) = \sum_{e \in P} \sum_{(x_1,x_2,x_3)ab \in V_1 \cup V_2} \widetilde{\mu}_e(x_1, x_2, x_3)(ab) = (3.6, 4.2, 3.1)$.

The degree of the vertices
$d_{\widetilde{G}_{P,V_1 \cup V_2}}(a_1) = (1.8, 2.2, 1.3), d_{\widetilde{G}_{P,V_1 \cup V_2}}(a_2) = (1.2, 1.6, 1.6)$,
$d_{\widetilde{G}_{P,V_1 \cup V_2}}(a_3) = (0.6, 0.4, 0.2), d_{\widetilde{G}_{P,V_1 \cup V_2}}(b_1) = (0.7, 1.0, 1.2)$,
$d_{\widetilde{G}_{P,V_1 \cup V_2}}(b_2) = (1.2, 2.0, 0.9), d_{\widetilde{G}_{P,V_1 \cup V_2}}(b_3) = (1.7, 1.2, 1.0)$.

4 Application of $3-$ polar soft fuzzy bi-partite graph in residence selection process

In the evolution of human life, the all-time dream of people is to own a residence, which is a symbol of status for some and it's a basic need for others. Primarily, people show an interest to buy a residence with a proper DTCP approval. Then, people also prefer eco-friendly environment, closely built neighbourhood, and good water facilities are added to a perfect residence selection. People are also cautious about buying their residence on a land surface not very close to well or lakes.

Let $V = V_1 \cup V_2 = \{V_1 : (a_1, a_2, a_3, a_4, a_5), V_2 : (b_1, b_2, b_3, b_4, b_5)\}$ be set of all two disjoint vertices and $P = \{e_1, e_2, e_3, e_4, e_5\}$ are parameterized set where

Exclusive amenities close by each types of residence $a_1, a_2, \ldots, a_5$ are given as follows:

a_1 - Airport, Motor Racing Track, Railway Station,

a_2 - Hospital, Top Professional Educational Institution, IT Park,

a_3 - Auto mobile hubs, IT Park, Railway Station,

a_4 - Temples, park, EB office,

a_5 - Motel Highway, Sipcot, Airport.

The exclusive in -built amenities of each type of residences $b_1, b_2, \ldots, b_5$ are as follows:

b_1 - Spill AC provision for all bedrooms, TV and Telephone points in all bed room, Kitchen and work area,

b_2 - Pressure checked plumbing, drainage line, 4 bed rooms,

b_3 - 2 bed rooms and separate toilet, living and dining room, car parking,

b_4 - Electronic surveillance, Two high speed elevators, 4 bed rooms,

b_5 - Swimming pool, 4 bed rooms, car parking.

and the parameters are

e_1-Residence closer to Industries and built with 3 bed rooms and modular Kitchen,

e_2-Residence closer to Educational Institution and built with living room and car parking,

e_3- Residence closer to get away with living room, car parking,

e_4-Residence closer to Highway and built with Swimming pool, 4 bed rooms,

e_5 -Residence closer to Airport and built with 2 bed rooms, kids area.

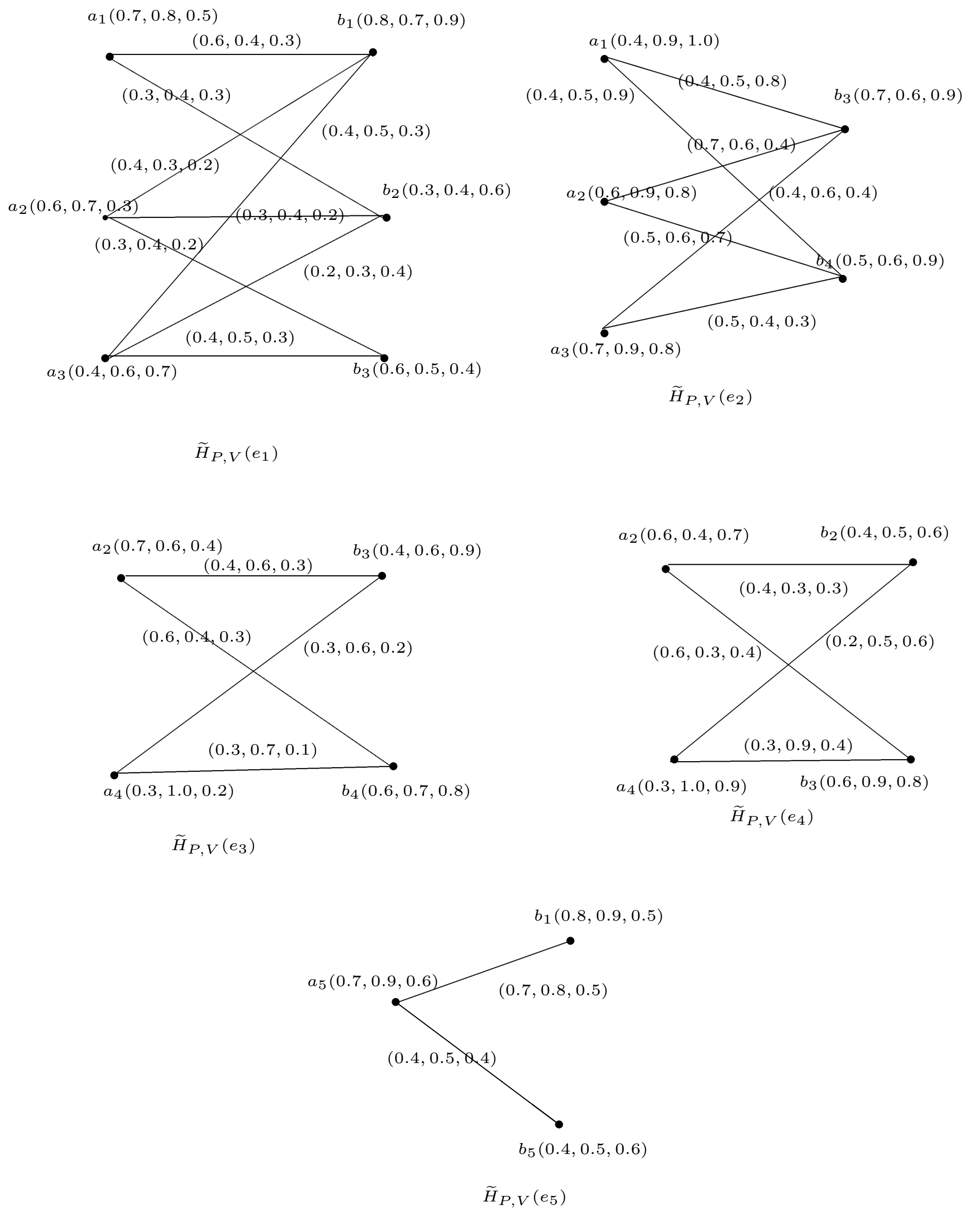

Figure 2 : $3-$polar fuzzy bi-partite graph

In Figure 2. The size of the each parameterized graph is calculated as

$$S(\widetilde{H}_{P,V}(e_1)) = \sum_{(x_1,x_2,x_3)ab\in V_1\cup V_2} \widetilde{\mu}_e(x_1,x_2,x_3)(ab) = (2.9, 3.2, 2.2),$$
$$S(\widetilde{H}_{P,V}(e_2)) = \sum_{(x_1,x_2,x_3)ab\in V_1\cup V_2} \widetilde{\mu}_e(x_1,x_2,x_3)(ab) = (2.9, 3.2, 3.5),$$

$$S(\widetilde{H}_{P,V}(e_3)) = \sum_{(x_1,x_2,x_3)ab\in V_1\cup V_2} \widetilde{\mu}_e(x_1,x_2,x_3)(ab) = (1.6, 2.3, 0.9),$$
$$S(\widetilde{H}_{P,V}(e_4)) = \sum_{(x_1,x_2,x_3)ab\in V_1\cup V_2} \widetilde{\mu}_e(x_1,x_2,x_3)(ab) = (1.5, 2.0, 1.7),$$
$$S(\widetilde{H}_{P,V}(e_5)) = \sum_{(x_1,x_2,x_3)ab\in V_1\cup V_2} \widetilde{\mu}_e(x_1,x_2,x_3)(ab) = (1.1, 1.3, 0.9).$$

From the above calculation, it is explicit that most of the people want their residence nearby Educational Institution, Hospital and built with bed room, living room and car parking.

To find the most preferable residence closer to various amenities, we are going to calculate degrees of each vertex.

$d_{\widetilde{H}_{P,V}(e)(a)}$	a_1	a_2	a_3	a_4	a_5
e_1	(0.9,0.8,0.6)	(1.0,1.1,0.6)	(1.0,1.3,1.0)	(0.0,0.0,0.0)	(0.0,0.0,0.0)
e_2	(0.8,1.0,1.7)	(1.2,1.2,1.1)	(0.9,1.0,0.7)	(0.0,0.0,0.0)	(0.0,0.0,0.0)
e_3	(0.0,0.0,0.0)	(1.0,1.0,0.6)	(0.0,0.0,0.0)	(0.6,1.3,0.3)	(0.0,0.0,0.0)
e_4	(0.0,0.0,0.0)	(1.0,0.6,0.7)	(0.0,0.0,0.0)	(0.5,1.4,1.0)	(0.0,0.0,0.0)
e_5	(0.0,0.0,0.0)	(0.0,0.0,0.0)	(0.0,0.0,0.0)	(0.0,0.0,0.0)	(1.1,1.3,0.9)
$d_{\widetilde{G}_{P,V}}(a)$	(1.7,1.8,2.3)	(4.2,3.9,3.0)	(1.9,2.3,1.7)	(1.1,2.7,1.3)	(1.1,1.3,0.9)

Table 1: Degree of each vertex according to closer by amenities in each type

$d_{\widetilde{H}_{P,V}(e)(b)}$	b_1	b_2	b_3	b_4	b_5
e_1	(1.4,1.2,0.8)	(0.8,1.1,0.9)	(0.7,0.9,0.5)	(0.0,0.0,0.0)	(0.0,0.0,0.0)
e_2	(0.0,0.0,0.0)	(0.0,0.0,0.0)	(1.5,1.7,1.6)	(1.4,1.5,1.9)	(0.0,0.0,0.0)
e_3	(0.0,0.0,0.0)	(0.0,0.0,0.0)	(0.7,1.2,0.5)	(0.9,1.1,0.4)	(0.0,0.0,0.0)
e_4	(0.0,0.0,0.0)	(0.6,0.8,0.9)	(0.9,1.2,0.8)	(0.0,0.0,0.0)	(0.0,0.0,0.0)
e_5	(0.7,0.8,0.5)	(0.0,0.0,0.0)	(0.0,0.0,0.0)	(0.0,0.0,0.0)	(0.4,0.5,0.4)
$d_{\widetilde{G}_{P,V}}(b)$	(2.1,2.0,1.3)	(1.4,1.9,1.8)	(3.8,5.0,3.4)	(2.3,2.6,2.3)	(0.4,0.5,0.4)

Table 2: Degree of each vertex according to in - built amenities

In above table, we have considered five different parameters and their corresponding exclusive amenities closer by each type of residence (table 1) and exclusive in-built amenities (table 2). The size of each parameterized graph is calculated and we have concluded the best parameter of buying house from the highest size.

Regarding closer by amenities: When the vertex a_2 dominates the other vertex, it is inferred that Educational institutions, Hospitals and IT parks are preferred over the rest.

In the case of residence: The vertex b_3 dominates the other qualities, the residence with 2 bed rooms and separated toilet, dining room and car parking is mostly preferred.

From the above calculation, we have revealed that most of the people want their residence nearby Educational Institutions, Hospitals and built with bed room, living room and car parking and also inferred that Educational institutions, Hospitals and IT parks are preferred over the rest and the residence with 2 bed rooms and separated toilet, dining room and car parking is mostly preferred.

5 Discussion and Conclusion

Bipartite graph is one of the important concepts in graph theory, which has wide applications since it's origination. Soft fuzzy graph is an interesting area in the field of research that most people are concentrating. S. Ramkumar and R. Sridevi [2021] introduced the concept of $m-$ polar soft fuzzy graph. In this article, Buying of own house is merely a challenge for every human being. So we are in need of considering many parameters to buy a new house as we are buying once in life time. This is the motivation behind this study. We consider m-polar soft fuzzy graph with various parameters and with the help of size of the graph we have chosen which one is the best. The parameters may vary from person to person. We have consider just five parameters according to our survey. It may also vary in rural and urban areas. In future, we have an idea to focus on any one of areas with accurate survey. Which would help us to conclude the best way of buying own house.

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