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Properties of Strong and Complete Intuitionistic Fuzzy Soft Graph

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Abstract: **In this paper, the notions of intuitionistic fuzzy soft graph, strong intuitionistic fuzzy soft graph and complete intuitionistic fuzzy soft graph are introduced. Also studied about the complement of the strong and complete intuitionistic fuzzy soft graph, and proved that the complement of a strong intuitionistic fuzzy soft graph is a strong intuitionistic fuzzy soft graph as well as the complement of a complete intuitionistic fuzzy soft graph is a complete intuitionistic fuzzy soft graph.**

Keywords: Intuitionistic fuzzy soft graph, Strong intuitionistic fuzzy soft graph, Complete Intuitionistic fuzzy soft graph, Complement intuitionistic fuzzy soft graph.

I. Introduction

In 2015, Akram and Nawaz [1] introduced the notions of fuzzy soft graphs, strong fuzzy soft graphs,complete fuzzy soft graphs, regular fuzzy soft graphs and investigated some of their properties. Akram and Nawaz [2] developed the concepts of soft graphs, vertex-induced soft graphs, edge-induced soft graphs and describe some operations on soft graphs. Akram and Nawaz [3] introduced the notions of soft trees, soft cycles, soft bridges, soft ctnodes and describe a various methods of construction of soft trees.

In 2016, Akram and Nawaz [4] presented concept of fuzzy soft graphs, certain types of irregular fuzzy soft graphs and described applications of fuzzy soft graphs in social network and road network. M.G.Karunambigai and R.Parvathi [5] introduced some new definitions for intuitionistic fuzzy soft graph and some of their properties are discussed. In 2011 M.G.Karunambigai, R.Parvathi and R.Bhuvaneswari[6] discussed about constant and total constant intuitionistic fuzzy soft graphs.In 2011 M.G.Karunambigai, R.Parvathi and R.Bhuvaneswari[7] discussed about arcs in constant and intuitionistic fuzzy soft graphs.

In 1999, Molodstov [8] introduced the concept of soft set theory to solve imprecise problems in the field of engineering, social science, economics, medical science and environment. Molodtsov [8,9] applied this theory to several directions such as smoothness of function, game theory, operation research, probability and measurement theory. In recent times, a number of researchers were more active doing research on soft set. Anas AI-Masarwah, Majdoleen Abu Qamar [10] introduced the complement of fuzzy soft graph and isolated fuzzy soft graph. A.M.Shyla and T.M.Mathew Varkey [11] discussed strong and complete intuitionistic fuzzy soft graph.

In this paper, the authors introduced some new concepts of intuitionistic fuzzy soft graphs, complement of strong and complete intuinionistic fuzzy soft graphs and isolated of intuitionistic fuzzy soft graphs.

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II. Preliminaries

Definition 2.1

Let V be a non-empty set. An intuitionistic fuzzy set A in V defined as A = $\{(V, \mu_A(v), \nu_A(v) \mid v \in V\}$ which is characterized by a membership function $\mu_A : V \to [0,1]$ and the non-membership function $\nu_A : V \to [0,1]$ and satisfying

i. $0 \le \mu_A(v) + \nu_A(v) \le 1 \quad \forall\, v \in V$

ii. $0 \le \mu_A(v), \nu_A(v), \pi_A(v) \le 1 \;\forall\; v \in V$.

iii. $\pi_A(v) = 1 - \mu_A(v) - \nu_A(v)$.

Where π_A is called the intuitionistic fuzzy index of the element v in A ; the value denotes the measure of non – determinancy. Obviously if $\pi_A(v) = 0$ forevery *v* in V, then the intuitionistic fuzzy set A is the extension of fuzzy analagues.

Definition 2.2

An intuitionsitic fuzzy graph is defined as G = (V, E, μ, ν). Where

1. Let $V = \{v_1, v_2 \dots v_n\}$ (non-empty set) such that $\mu_1 : V \to [0,1]$ and $\gamma_1 : V \to [0,1]$ denote the degree of membership and non-membership of the element $v_i \in V$ respectively and $0 \le \mu_i(v_i) + \nu_i(v_i) \le 1$ forevery $v_i \in V$, i = 1,2….n.

2.E$\subset V \times V$ where $\mu_{ij} : V \to [0,1]$ and $\nu_{ij} : V \to [0,1]$ are such that

i. $\mu_{ij}(v_i, v_j) \le \min\{\mu_i(v_i), \mu_i(v_j)\}$

ii. $\nu_{ij}(v_i, v_j) \le \max\{\nu_i(v_i), \nu_i(v_j)\}$ and

iii. $0 \le \mu_{ij}(v_i, v_j) + \nu_{ij}(v_i, v_j) \le 1$,

$$0 \le \mu_{ij}(v_i, v_j), \nu_{ij}(v_i, v_j), \pi(v_i, v_j) \le 1$$

Where $\pi(v_i, v_j) = 1 - \mu_{ij}(v_i, v_j) - \nu_{ij}(v_i, v_j)$. forevery $(v_i, v_j) \in E$, i , j = 1,2…. n.

Definition 2.3

A pair ($\grave{F}$,A) is called intuitionistic fuzzy soft set over U, where $\grave{F}$ is the mapping given by $\grave{F}$:A$\to IF^U$; IF^U denotes the collection of all intuitionistic fuzzy subsets of U; A$\subseteq P$.

Definition 2.4

Let G= (V,E) be a simple graph, $V = \{v_1, v_2 \dots v_n\}$ (non-empty set), E$\subseteq V \times V$, P (parameter set) and $A \subseteq P$ .Also let

1. μ_i is a membership function defined on *V* by $\mu_i : A \to IF^U(V)$ ($IF^U(V)$ denotes collection of all intuitionistic fuzzy subsets in V) aα $\mu_i(a) = \mu_{ia}$ (say),a$\in A$ and $\mu_{ia} : V \to [0,1]$, v_i α $\mu_{ia}(v_i)$ (A, μ_i) Intuitionistic fuzzy soft vertex of membership function and

ν_i is a membership function defined on V by $\nu_i : A \to IF^U(V)$ ($IF^U(V)$ denotes collection of all intuitionistic fuzzy subsets in V) aα $\nu_i(a) = \nu_{ia}$ (say) , a$\in A$ and $\nu_{ia} : V \to [0,1]$, v_i α $\nu_{ia}(v_i)$ (A,ν_i) Intuitionistic fuzzy soft vertex of membership function such that $0 \le \mu_{ia}(v_i) + \nu_{1a}(v_i) \le 1$,forevery $v_i \in V$, i=1,2,….n and a$\in A$.

2. μ_{ij} is a membership function defined on E by

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$\mu_{ij} : A \to IF^U(V \times V)$ ($IF^U(V \times V)$ denotes collection of all intuitionistic fuzzy subsets in E)

a α $\mu_{ij}(a) = \mu_{ija}$ (say),a $\in A$ and $\mu_{ija} : V \times V \to [0,1]$,

(v_i, v_j) α $\mu_{ija}(v_i, v_j)$

ν_{ij} is a non-membership function defined on E by

$\nu_{ij} : A \to IF^U(V \times V)$ ($IF^U(V \times V)$ denotes collection of all intuitionistic fuzzy subsets in E)

a α $\nu_{ij}(a) = \nu_{ija}$ (say),a $\in A$ and $\nu_{ija} : V \times V \to [0,1]$,

(v_i, v_j) α $\nu_{ija}(v_i, v_j)$

where ((A, μ_{ij}) ,(A, ν_{ij})) are intuitionistic fuzzy soft edge of membership and non-membership function satisfying

$$\mu_{ija}(v_i, v_j) \le \min\{\mu_{ia}(v_i), \mu_{ia}(v_j)\}$$

$$\nu_{ija}(v_i, v_j) \le \max\{\nu_{ia}(v_i), \nu_{ia}(v_j)\} \text{ and}$$

$$0 \le \mu_{ija}(v_i, v_j) + \nu_{ija}(v_i, v_j) \le 1,$$

$0 \le \mu_{ija}(v_i, v_j), \nu_{ija}(v_i, v_j) \le 1$, forevery $(v_i, v_j) \in E$, i ,j = 1,2…. n and a $\in A$

Then $G^* = (V, E, (\mathrm{A}, \mu_1), (\mathrm{A}, \gamma_1), (\mathrm{A}, \mu_2), (\mathrm{A}, \gamma_2))$ is said to be Intuitionistic fuzzy soft graph (IFSG) and this IFSG is denoted by $G^*_{A,V,E}$.

Definition 2.5

An intuitionistic fuzzy soft graph $G^* = (V, E, (\mathrm{A}, \mu_i), (\mathrm{A}, \nu_i), (\mathrm{A}, \mu_{ij}), (\mathrm{A}, \nu_{ij}))$ is said to be strong intuitionistic fuzzy soft graph if

$$\mu_{ija}(v_i, v_j) = \min\{\mu_{ia}(v_i), \mu_{ia}(v_j)\} \text{ and}$$

$$\nu_{ija}(v_i, v_j) = \max\{\nu_{ia}(v_i), \nu_{ia}(v_j)\}$$

forevery $(v_i, v_j) \in E$, and a $\in A$

Definition 2.6

An intuitionistic fuzzy soft graph $G^* = (V, E, (\mathrm{A}, \mu_i), (\mathrm{A}, \nu_i), (\mathrm{A}, \mu_{ij}), (\mathrm{A}, \nu_{ij}))$ is said to be strong intuitionistic fuzzy soft graph if

$$\mu_{ija}(v_i, v_j) = \min\{\mu_{ia}(v_i), \mu_{ia}(v_j)\} \text{ and}$$

$$\nu_{ija}(v_i, v_j) = \max\{\nu_{ia}(v_i), \nu_{ia}(v_j)\}$$

forevery $v_i, v_j \in V$, and a $\in A$.

Definition 2.7

Let $G^*_{A,V,E} = (V, E, (\mathrm{A}, \mu_i), (\mathrm{A}, \nu_i), (\mathrm{A}, \mu_{ij}), (\mathrm{A}, \nu_{ij}))$ be an intuitionistic fuzzy soft graph. The complement of a $G^*_{A,V,E}$ is defined as

$$\overline{G^*_{A,V,E}} = (V, E, (\mathrm{A}, \mu_i), (\mathrm{A}, \nu_i), \overline{(A, \mu_{ij})}, \overline{(A, \nu_{ij})})$$

where $\overline{\mu_{ija}}(v_i, v_j) = \mu_{ia}(v_i) \wedge \mu_{ia}(v_j) - \mu_{ija}(v_i, v_j)$

$$\overline{\nu_{ija}}(v_i, v_j) = \nu_{ia}(v_i) \vee \nu_{ia}(v_j) - \nu_{ija}(v_i, v_j)$$

forall $v_i, v_j \in V, a \in A$.

III. Main Results of Intuitionistic Fuzzy Soft Graph

Theorem 3.1

The complement of a strong intuitionistic fuzzy soft graph is a strong intuitionistic fuzzy soft graph.

Proof

An intuitionistic fuzzy soft graph $G^* = (V, E, (\mathrm{A}, \mu_i), (\mathrm{A}, \nu_i), (\mathrm{A}, \mu_{ij}), (\mathrm{A}, \nu_{ij}))$ is said to be strong intuitionistic fuzzy soft graph if

$$\mu_{ija}(v_i, v_j) = \min\{\mu_{ia}(v_i), \mu_{ia}(v_j)\} \text{ and}$$

$$\nu_{ija}(v_i, v_j) = \max\{\nu_{ia}(v_i), \nu_{ia}(v_j)\}$$

forevery$(v_i, v_j) \in E$, and a $\in A$

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By the definition of complement for a membership function is,

$$\overline{\mu_{ija}}(v_i,v_j) = \mu_{ia}(v_i)\wedge\mu_{ia}(v_j) - \mu_{ija}(v_i,v_j)$$

$$= \begin{cases} \mu_{ia}(v_i)\wedge\mu_{ia}(v_j) - \mu_{ia}(v_i)\wedge\mu_{ia}(v_j), \mu_{ija}(v_i,v_j) > 0 \\ \mu_{ia}(v_i)\wedge\mu_{ia}(v_j), \mu_{ija}(v_i,v_j) = 0 \end{cases}$$

$$= \begin{cases} 0, \mu_{ija}(v_i,v_j) > 0 \\ \mu_{ia}(v_i)\wedge\mu_{ia}(v_j), \mu_{ija}(v_i,v_j) = 0 \end{cases}$$

$$\overline{\mu_{ija}}(v_i,v_j) = \begin{cases} 0, & \overline{\mu_{ija}}(v_i,v_j) = 0 \\ \mu_{ia}(v_i)\wedge\mu_{ia}(v_j), & \overline{\mu_{ija}}(v_i,v_j) > 0 \end{cases}$$

By the definition of complement for a non-membership function is,

$$\overline{\nu_{ija}}(v_i,v_j) = \nu_{ia}(v_i)\vee\nu_{ia}(v_j) - \nu_{ija}(v_i,v_j)$$

$$= \begin{cases} \nu_{ia}(v_i)\vee\nu_{ia}(v_j) - \nu_{ia}(v_i)\vee\nu_{ia}(v_j), \nu_{ija}(v_i,v_j) < 0 \\ \nu_{ia}(v_i)\wedge\nu_{ia}(v_j), \nu_{ija}(v_i,v_j) = 0 \end{cases}$$

$$= \begin{cases} 0, \nu_{ija}(v_i,v_j) < 0 \\ \nu_{ia}(v_i)\vee\nu_{1a}(v_j), \nu_{ija}(v_i,v_j) = 0 \end{cases}$$

$$\overline{\nu_{ija}}(v_i,v_j) = \begin{cases} 0, & \overline{\nu_{ija}}(v_i,v_j) = 0 \\ \nu_{ia}(v_i)\vee\nu_{ia}(v_j), & \overline{\nu_{ija}}(v_i,v_j) < 0 \end{cases}$$

$\overline{\mu_{ija}}(v_i,v_j) = \mu_{ia}(v_i)\wedge\mu_{ia}(v_j)$, $\overline{\mu_{ija}}(v_i,v_j) = 0$ and

$\overline{\nu_{ija}}(v_i,v_j) = \nu_{ia}(v_i)\vee\nu_{ia}(v_j)$, $\overline{\nu_{ija}}(v_i,v_j) = 0$

forevery $(v_i,v_j)\in E$, and $a\in A$, where v_iv_j denote the edge for all $(v_i,v_j)\in\overline{\mu}^*, \overline{\nu}^*$.

Thus, the complement of a strong intuitionistic fuzzy soft graph is a strong intuitionistic fuzzy soft graph.

Theorem 3.2

The complement of a complete intuitionistic fuzzy soft graph is a complete intuitionistic fuzzy soft graph.

Proof

An intuitionistic fuzzy soft graph $G^* = (V, E, (A,\mu_i), (A,\nu_i), (A,\mu_{ij}), (A,\nu_{ij}))$ is said to be complete intuitionistic fuzzy soft graph. if

$\mu_{ija}(v_i,v_j) = \min\{\mu_{ia}(v_i), \mu_{ia}(v_j)\}$ and

$\nu_{ija}(v_i,v_j) = \max\{\nu_{ia}(v_i), \nu_{ia}(v_j)\}$ forevery

$(v_i,v_j)\in V$, and $a\in A$

By the definition of complement for a membership function is,

$$\overline{\mu_{ija}}(v_i,v_j) = \mu_{ia}(v_i)\wedge\mu_{ia}(v_j) - \mu_{ija}(v_i,v_j)$$

$$= \begin{cases} \mu_{ia}(v_i)\wedge\mu_{ia}(v_j) - \mu_{ia}(v_i)\wedge\mu_{ia}(v_j), \mu_{ija}(v_i,v_j) > 0 \\ \mu_{ia}(v_i)\wedge\mu_{ia}(v_j), \mu_{ija}(v_i,v_j) = 0 \end{cases}$$

$$= \begin{cases} 0, \mu_{ija}(v_i,v_j) > 0 \\ \mu_{ia}(v_i)\wedge\mu_{ia}(v_j), \mu_{ija}(v_i,v_j) = 0 \end{cases}$$

$$\overline{\mu_{ija}}(v_i,v_j) = \begin{cases} 0, & \overline{\mu_{ija}}(v_i,v_j) = 0 \\ \mu_{ia}(v_i)\wedge\mu_{ia}(v_j), & \overline{\mu_{ija}}(v_i,v_j) > 0 \end{cases}$$

By the definition of complement for a non-membership function is,

$$\overline{\nu_{ija}}(v_i,v_j) = \nu_{ia}(v_i)\vee\nu_{ia}(v_j) - \nu_{ija}(v_i,v_j)$$

$$= \begin{cases} \nu_{ia}(v_i)\vee\nu_{ia}(v_j) - \nu_{ia}(v_i)\vee\nu_{ia}(v_j), \nu_{ija}(v_i,v_j) < 0 \\ \nu_{ia}(v_i)\wedge\nu_{ia}(v_j), \nu_{ija}(v_i,v_j) = 0 \end{cases}$$

$$= \begin{cases} 0, \nu_{ija}(v_i,v_j) < 0 \\ \nu_{ia}(v_i)\vee\nu_{1a}(v_j), \nu_{ija}(v_i,v_j) = 0 \end{cases}$$

$$\overline{\nu_{ija}}(v_i,v_j) = \begin{cases} 0, & \overline{\nu_{ija}}(v_i,v_j) = 0 \\ \nu_{ia}(v_i)\vee\nu_{ia}(v_j), & \overline{\nu_{ija}}(v_i,v_j) < 0 \end{cases}$$

$\overline{\mu_{ija}}(v_i,v_j) = \mu_{ia}(v_i)\wedge\mu_{ia}(v_j)$, $\overline{\mu_{ija}}(v_i,v_j) = 0$ and

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$\overline{\nu_{ija}}(v_i, v_j) = \nu_{ia}(v_i) \vee \nu_{ia}(v_j)$, $\overline{\nu_{ija}}(v_i, v_j) = 0$ for every $(v_i, v_j) \in E$, and $a \in A$, where v_i, v_j denote the edge for all $v_i, v_j \in \overline{\mu}^*, \overline{\nu}^*$.

Thus, the complement of a complete intuitionistic fuzzy soft graph is a complete intuitionistic fuzzy soft graph.

Theorem 3.3

Let $G^*_{A,V,E} = (V, E, (\mathrm{A}, \mu_i), (\mathrm{A}, \nu_i), (\mathrm{A}, \mu_{ij}), (\mathrm{A}, \nu_{ij})$ be an intuitionistic fuzzy soft graph. Then $G^*_{A,V,E}$ is an isolated intuitionistic fuzzy soft graph if and only if $\overline{G^*_{A,V,E}}$ is a complete intuitionistic fuzzy soft graph.

Proof

Let $G^*_{A,V,E} = (V, E, (\mathrm{A}, \mu_i), (\mathrm{A}, \nu_i), (\mathrm{A}, \mu_{ij}), (\mathrm{A}, \nu_{ij})$ be an intuitionistic fuzzy soft graph.

The complement of a $G^*_{A,V,E}$ is defined as $\overline{G^*_{A,V,E}}$

$\overline{\mu_{ija}}(v_i, v_j) = 0$ $\overline{\nu_{ija}}(v_i, v_j) = 0$ $\forall$ $v_i, v_j \in V \times V, a \in A$.

Since

$$\overline{\mu_{ija}}(v_i, v_j) = \mu_{ia}(v_i) \wedge \mu_{ia}(v_j) - \mu_{ija}(v_i, v_j)$$

for all $v_i, v_j \in V \times V, a \in A$.

$$\overline{\mu_{ija}}(v_i, v_j) = \mu_{ia}(v_i) \wedge \mu_{ia}(v_j)$$

forall $v_i, v_j \in V \times V, a \in A$.

$$\overline{\nu_{ija}}(v_i, v_j) = \nu_{ia}(v_i) \vee \nu_{ia}(v_j) - \nu_{ija}(v_i, v_j)$$

for all $v_i, v_j \in V \times V, a \in A$.

$$\overline{\nu_{ija}}(v_i, v_j) = \nu_{ia}(v_i) \vee \nu_{ia}(v_j)$$

forall $v_i, v_j \in V \times V, a \in A$.

$\overline{\mu_{ija}}(v_i, v_j) = \mu_{ia}(v_i) \wedge \mu_{ia}(v_j)$,

$\overline{\nu_{ija}}(v_i, v_j) = \nu_{ia}(v_i) \vee \nu_{ia}(v_j)$

for all $v_i, v_j \in V \times V, a \in A$.

Hence $\overline{G^*_{A,V,E}}$ is a complete intuitionistic fuzzy soft graph.

Conversely,

Given $\overline{G^*_{A,V,E}}$ is a complete intuitionistic fuzzy soft graph.

$\overline{\mu_{ija}}(v_i, v_j) = \mu_{ia}(v_i) \wedge \mu_{ia}(v_j)$,

$\overline{\nu_{ija}}(v_i, v_j) = \nu_{ia}(v_i) \vee \nu_{ia}(v_j)$

for all $v_i, v_j \in V \times V, a \in A$.

Since

$$\mu_{ija}(v_i, v_j) = \mu_{ia}(v_i) \wedge \mu_{ia}(v_j) - \overline{\mu_{ija}}(v_i, v_j)$$

for all $v_i, v_j \in V \times V, a \in A$.

$$= \overline{\mu_{ija}}(v_i, v_j) - \overline{\mu_{ija}}(v_i, v_j) \ \forall v_i, v_j \in V \times V, a \in A.$$

$\mu_{ija}(v_i, v_j) = 0$ for all $v_i, v_j \in V \times V, a \in A$.

$$\nu_{ija}(v_i, v_j) = \nu_{ia}(v_i) \vee \nu_{ia}(v_j) - \overline{\nu_{ija}}(v_i, v_j)$$

for all $v_i, v_j \in V \times V, a \in A$

$$= \overline{\nu_{ija}}(v_i, v_j) - \overline{\nu_{ija}}(v_i, v_j) \ \forall \ v_i, v_j \in V \times V, a \in A.$$

$\nu_{ija}(v_i, v_j)$ =0 for all $v_i, v_j \in V \times V, a \in A$.

$\mu_{ija}(v_i, v_j)$=0, $\nu_{ija}(v_i, v_j)$=0 $\forall$ $v_i, v_j \in V \times V, a \in A$

Hence, $G^*_{A,V,E}$ is an isolated intuitionistic fuzzy soft graph.

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IV.Conclusion

In this paper, basic definitions of intuitionistic fuzzy soft graphs, complete and strong intuitionistic fuzzy soft graphs are introduced. Also some results about strong intuitionistic fuzzy soft graphs,complete intuitionistic fuzzy soft graphs and isolated intuitionistic fuzzy soft graphs with their complements construced. In future, the author proposed to continue this result in regular intuitionistic fuzzy soft graphs and interval-valued intuitionistic fuzzy soft graphs.

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