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COMPLEMENT AND μ-COMPLEMENT OF INTUITIONISTIC FUZZY SOFT GRAPH

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Abstract

In this paper, the basic definitions of intuitionistic fuzzy soft graph, strong and complete intuitionistic fuzzy soft graph are introduced. The notions of complement and μ-complement of intuitionistic fuzzy soft graph are introduced and also some of their properties are investigated.

Keywords - Intuitionistic fuzzy soft graph, Strong IFSG, Complete IFSG, μ-Complement IFSG.

1.Introduction

In 1999, Soft set theory is applied to smooth of functions, game theory, operations research, probability and measurement theory by Molodstov[1,2]. The notions of soft trees, soft cycles, soft bridges, soft ctnodes and describe a various methods of construction of soft trees are discussed by Akram and Nawaz [3].

The concept of soft set theory to solve imprecise problems in the field of engineering, social science, economics, medical science and environment are discussed Molodstov [4] in 1999. Molodtsov [4,5] applied soft set theory to several directions. In recent times, a number of researchers were more active doing research on soft set. Anas AI-Masarwah, Majdoleen Abu Qamar [6] discussed about the complement of fuzzy soft graph and isolated fuzzy soft graph. A.M.Shyla and T.M.Mathew Varkey [7] discussed strong and complete intuitionistic fuzzy soft graph.

In this paper the author discussed about the μ-complements of intuitionistic fuzzy soft graph.

2.PRELIMINARIES

Definition 2.1

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

Definition 2.2

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

1. μ_i is a function defined on V by

$\mu_i : A \to F^U(V)$ ($F^U(V)$ denotes collection of all fuzzy subsets in V)

a $\mapsto \mu_i(a) = \mu_{ia}$ (say) , a $\in A$ and $\mu_{ia} : V \to [0,1]$, $v_i \mapsto \mu_{ia}(v_i)$

(A, μ_i) fuzzy soft vertex and

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

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

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

(A, μ_{ij}) fuzzy soft edge.

A pair ((A, μ_i),(A, μ_{ij})) is called a fuzzy soft graph. If $\mu_{ija}(v_i, v_j) = \mu_{ia}(v_i) \wedge \mu_{ia}(v_j)$ $\forall$

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

Definition 2.3

A pair ($\breve{F}$,A) is called intuitionistic fuzzy soft set over U, where $\breve{F}$ is a mapping given by the $\breve{F}$: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= $\{v_1, v_2 \ldots v_n\}$ (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)

a $\mapsto \mu_i(a) = \mu_{ia}$ (say), a $\in A$ and $\mu_{ia} : V \to [0,1]$, $v_i \mapsto \mu_{ia}(v_i)$

(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)

a $\mapsto \nu_i(a) = \nu_{ia}$ (say), a $\in A$ and $\nu_{ia} : V \to [0,1]$, $v_i \mapsto \nu_{ia}(v_i)$

(A, ν_i) Intuitionistic fuzzy soft vertex of membership function such that

$0 \le \mu_{ia}(v_i) + \nu_{1a}(v_i) \le 1$, for every $v_i \in V$, i=1,2,….n and a $\in A$.

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

$\mu_{ij} : A \to IF^U(V \times V)$ ($IF^U(V \times V)$ denotes collection of all intuitionistic fuzzy subsets in E) a$\mapsto \mu_{ij}(a) = \mu_{ija}$ (say) , a$\in A$ and $\mu_{ija} : V \times V \to [0,1]$, $(v_i, v_j) \mapsto \mu_{ija}(v_i, v_j)$

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

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

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

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

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

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

Definition 2.5

Let $G_{A,V,E}$ be an intuitionistic fuzzy soft graph. It is said to be strong intuitionistic fuzzy soft graph if $\mu_{ija}(v_i, v_j) = \min\{\mu_{ia}(v_i), \mu_{ia}(v_j)\}$ 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

Let $G_{A,V,E}$ be an intuitionistic fuzzy soft graph. It 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$\in A$

Definition 2.7

Let $G_{A,V,E}$ be an intuitionistic fuzzy soft graph. The complement of a $G_{A,V,E}$ is defined as $\overline{G_{A,V,E}}$ = $(V, E, (A, \mu_i), (A, \nu_i), \overline{(A, \mu_{ij})}, \overline{(A, \nu_{ij})})$ where

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

$$\overline{\nu_{ija}}(v_i, v_j) = \nu_{ia}(v_i) \vee \nu_{ia}(v_j) - \nu_{ija}(v_i, v_j) \text{ for all } v_i, v_j \in V, a \in A.$$

Definition 2.8

If $G_{A,V,E}$ be an intuitionistic fuzzy soft graph. $G^{\mu}_{A,V,E}$ is a μ- complement of a $G_{A,V,E}$ is defined as $G^{\mu}_{A,V,E}$ = $(V, E, (A, \mu_i), (A, \nu_i), (A, \mu_{ij})^{\mu}, (A, \nu_{ij})^{\mu})$ where

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

$$\nu_{ija}^{\mu}\ (v_i, v_j) = \nu_{ia}(v_i) \vee \nu_{ia}(v_j) - \nu_{ija}(v_i, v_j) \text{ for all } v_i, v_j \in V, a \in A.$$

3. Main results of IFSG

Theorem 3.1

If $G_{A,V,E}$ 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 strong intuitionistic fuzzy soft graph.

Proof

Given $G_{A,V,E}$ be an intuitionistic fuzzy soft graph. The complement of a $G_{A,V,E}$ is defined by $\overline{G_{A,V,E}}$

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

Since

$$\overline{\mu_{ija}}(v_i, v_j) = \mu_{ia}(v_i) \wedge \mu_{ia}(v_j) - \mu_{ija}(v_i, v_j) \text{ for all } v_i, v_j \in V \times V, a \in A.$$

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

$$\overline{\nu_{ija}}(v_i, v_j) = \nu_{ia}(v_i) \vee \nu_{ia}(v_j) - \nu_{ija}(v_i, v_j) \text{ for all } v_i, v_j \in V \times V, a \in A.$$

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

$$\overline{\mu_{ija}}(v_i, v_j) = \mu_{ia}(v_i) \wedge \mu_{ia}(v_j), \overline{\nu_{ija}}(v_i, v_j) = \nu_{ia}(v_i) \vee \nu_{ia}(v_j) \text{ for all } v_i, v_j \in V \times V, a \in A.$$

Hence $\overline{G_{A,V,E}}$ is a strong intuitionistic fuzzy soft graph.

Conversely,

Given $\overline{G_{A,V,E}}$ is a strong intuitionistic fuzzy soft graph.

$$\overline{\mu_{ija}}(v_i, v_j) = \mu_{ia}(v_i) \wedge \mu_{ia}(v_j)\ ,\ \overline{\nu_{ija}}(v_i, v_j) = \nu_{ia}(v_i) \vee \nu_{ia}(v_j) \text{ for all } v_i, v_j \in V \times V, a \in A.$$

Since

$$\mu_{ija}(v_i, v_j) = \mu_{ia}(v_i) \wedge \mu_{ia}(v_j) - \overline{\mu_{ija}}(v_i, v_j) \text{ for all } v_i, v_j \in V \times V, a \in A.$$

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

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

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

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

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

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

Hence, $G_{A,V,E}$ is an isolated intuitionistic fuzzy soft graph.

Theorem 3.2

If $G_{A,V,E} = (V,E,(A,\mu_i),(A,\nu_i),(A,\mu_{ij}),(A,\nu_{ij}))$ be an intuitionistic fuzzy soft graph. Then $G^{\mu}_{A,V,E}$ is an isolated intuitionistic fuzzy soft graph if and only if $G_{A,V,E}$ is a strong intuitionistic fuzzy soft graph.

Proof

Given $G_{A,V,E} = (V,E,(A,\mu_i),(A,\nu_i),(A,\mu_{ij}),(A,\nu_{ij}))$ be an intuitionistic fuzzy soft graph. The μ-complement of $G_{A,V,E}$ is denoted by $G^{\mu}_{A,V,E}$. Let $G_{A,V,E} = (V,E,(A,\mu_i),(A,\nu_i),(A,\mu_{ij}),(A,\nu_{ij}))$ be an strong intuitionistic fuzzy soft graph. If

$\mu_{ija}(v_i,v_j) = \mu_{ia}(v_i)\wedge\mu_{ia}(v_j)$ and $\nu_{ija}(v_i,v_j) = \nu_{ia}(v_i)\vee\nu_{ia}(v_j)\ \forall (v_i,v_j)\in E$ and $a\in A$

otherwise

$$\mu_{ija}(v_i,v_j) = 0 \text{ and } \nu_{ija}(v_i,v_j) = 0$$

By the definition of μ-complement and from equations (1) and (2)

$$\mu^{\mu}_{ija}(v_i,v_j) = 0 \text{ and } \nu^{\mu}_{ija}(v_i,v_j) = 0\ \forall (v_i,v_j)\in E \text{ and } a\in A$$

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

Conversely,

Assume $G^{\mu}_{A,V,E}$ is an isolated intuitionistic fuzzy soft graph.

For a membership function

$\Rightarrow \mu^{\mu}_{ija}(v_i,v_j) = 0\ \forall (v_i,v_j)\in E$ and $a\in A$

$\Rightarrow \mu^{\mu}_{ija}(v_i,v_j) = 0\ \forall (v_i,v_j)\in \mu^*$ and $(v_i,v_j)\notin \mu^*$ $a\in A$

From the definition if $(v_i,v_j)\in \mu^*$

$\mu^{\mu}_{ija}(v_i,v_j) = \mu_{ia}(v_i)\wedge\mu_{ia}(v_j) - \mu_{ija}(v_i,v_j)$

Since

$\mu_{ija}^{\mu}\ (v_i, v_j) = 0$

$0 = \mu_{ia}(v_i) \wedge \mu_{ia}(v_j) - \mu_{ija}(v_i, v_j)\ \ \forall (v_i, v_j) \in E$ and $a \in A$

$\mu_{ija}(v_i, v_j) = \mu_{ia}(v_i) \wedge \mu_{ia}(v_j)\ \forall (v_i, v_j) \in E$ and $a \in A$

For a non-membership function

$\Rightarrow \qquad \nu_{ija}^{\mu}\ (v_i, v_j) = 0\ \forall (v_i, v_j) \in E$ and $a \in A$

$\Rightarrow \qquad \nu_{ija}^{\mu}\ (v_i, v_j) = 0\ \forall (v_i, v_j) \in \nu^*$ and $(v_i, v_j) \notin \nu^*$ $a \in A$

From the definition if $(v_i, v_j) \in \nu^*$

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

Since

$\nu_{ija}^{\mu}\ (v_i, v_j) = 0$

$\Rightarrow \qquad 0 = \nu_{ia}(v_i) \vee \nu_{ia}(v_j) - \nu_{ija}(v_i, v_j)\ \ \forall (v_i, v_j) \in E$ and $a \in A$

$\Rightarrow \qquad \nu_{ija}(v_i, v_j) = \nu_{ia}(v_i) \vee \nu_{ia}(v_j)\ \forall (v_i, v_j) \in E$ and $a \in A$

Therefore,

$\mu_{ija}(v_i, v_j) = \mu_{ia}(v_i) \wedge \mu_{ia}(v_j)$ and $\nu_{ija}(v_i, v_j) = \nu_{ia}(v_i) \vee \nu_{ia}(v_j)\ \forall (v_i, v_j) \in E$ and $a \in A$

Hence,

$G_{A,V,E} = (V, E, (\text{A}, \mu_i), (\text{A}, \nu_i), (\text{A}, \mu_{ij}), (\text{A}, \nu_{ij}))$ be an strong intuitionistic fuzzy soft graph.

Theorem 3.3

If $G_{A,V,E} = (V, E, (\text{A}, \mu_i), (\text{A}, \nu_i), (\text{A}, \mu_{ij}), (\text{A}, \nu_{ij}))$ be an intuitionistic fuzzy soft graph. Then $G_{A,V,E}^{\mu}$ is an isolated intuitionistic fuzzy soft graph if and only if $G_{A,V,E}$ is a complete intuitionistic fuzzy soft graph.

Proof

Given $G_{A,V,E} = (V, E, (\text{A}, \mu_i), (\text{A}, \nu_i), (\text{A}, \mu_{ij}), (\text{A}, \nu_{ij}))$ be an intuitionistic fuzzy soft graph. The μ-complement of $G_{A,V,E}$ is denoted by $G_{A,V,E}^{\mu}$. Let $G_{A,V,E} = (V, E, (\text{A}, \mu_i), (\text{A}, \nu_i), (\text{A}, \mu_{ij}), (\text{A}, \nu_{ij}))$ be an strong intuitionistic fuzzy soft graph. If

$\mu_{ija}(v_i,v_j) = \mu_{ia}(v_i) \wedge \mu_{ia}(v_j)$ and $\nu_{ija}(v_i,v_j) = \nu_{ia}(v_i) \vee \nu_{ia}(v_j)\ \forall (v_i,v_j) \in E$ and $a \in A$ otherwise

$$\mu_{ija}(v_i,v_j) = 0 \text{ and } \nu_{ija}(v_i,v_j) = 0$$

By the definition of μ-complement and from equations (1) and (2)

$$\mu^{\mu}_{ija}(v_i,v_j) = 0 \text{ and } \nu^{\mu}_{ija}(v_i,v_j) = 0\ \forall (v_i,v_j) \in E \text{ and } a \in A$$

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

Conversely,

Assume $G^{\mu}_{A,V,E}$ is an isolated intuitionistic fuzzy soft graph.

For a membership function

$\Rightarrow \mu^{\mu}_{ija}(v_i,v_j) = 0\ \forall (v_i,v_j) \in E$ and $a \in A$

$\Rightarrow \mu^{\mu}_{ija}(v_i,v_j) = 0\ \forall (v_i,v_j) \in \mu^*$ and $(v_i,v_j) \notin \mu^*$ $a \in A$

From the definition if $(v_i,v_j) \in \mu^*$

$\mu^{\mu}_{ija}(v_i,v_j) = \mu_{ia}(v_i) \wedge \mu_{ia}(v_j) - \mu_{ija}(v_i,v_j)$

Since

$\mu^{\mu}_{ija}(v_i,v_j) = 0$

$0 = \mu_{ia}(v_i) \wedge \mu_{ia}(v_j) - \mu_{ija}(v_i,v_j)\ \forall (v_i,v_j) \in E$ and $a \in A$

$\mu_{ija}(v_i,v_j) = \mu_{ia}(v_i) \wedge \mu_{ia}(v_j)\ \forall (v_i,v_j) \in E$ and $a \in A$

For a non-membership function

$\Rightarrow \quad \nu^{\mu}_{ija}(v_i,v_j) = 0\ \forall (v_i,v_j) \in E$ and $a \in A$

$\Rightarrow \quad \nu^{\mu}_{ija}(v_i,v_j) = 0\ \forall (v_i,v_j) \in \nu^*$ and $(v_i,v_j) \notin \nu^*$ $a \in A$

From the definition if $(v_i,v_j) \in \nu^*$

$\nu^{\mu}_{ija}(v_i,v_j) = \nu_{ia}(v_i) \vee \nu_{ia}(v_j) - \nu_{ija}(v_i,v_j)$

Since

$$\nu_{ija}^{\mu}\ (v_i, v_j) = 0$$

$$\Rightarrow \qquad 0 = \nu_{ia}(v_i) \vee \nu_{ia}(v_j) - \nu_{ija}(v_i, v_j) \quad \forall (v_i, v_j) \in E \text{ and } a \in A$$

$$\Rightarrow \qquad \nu_{ija}(v_i, v_j) = \nu_{ia}(v_i) \vee \nu_{ia}(v_j) \ \forall (v_i, v_j) \in E \text{ and } a \in A$$

Therefore,

$$\mu_{ija}(v_i, v_j) = \mu_{ia}(v_i) \wedge \mu_{ia}(v_j) \text{ and } \nu_{ija}(v_i, v_j) = \nu_{ia}(v_i) \vee \nu_{ia}(v_j) \ \forall (v_i, v_j) \in E \text{ and } a \in A$$

Hence,

$G_{A,V,E} = (V, E, (A, \mu_i), (A, \nu_i), (A, \mu_{ij}), (A, \nu_{ij}))$ be an complete intuitionistic fuzzy soft graph.

Conclusion

In this paper, the definitions of intuitionistic fuzzy soft graphs, complete and strong intuitionistic fuzzy soft graphs are discussed. Also studied about their µ-complement. In future, the author proposed to continue this result in interval-valued intuitionistic fuzzy soft graphs and self-complementary intuitionistic fuzzy soft graphs.

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