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INTUITIONISTIC FUZZY SEMI δ -PRE IRRESOLUTE MAPPINGS

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Abstract. This paper introduces the concept of intuitionistic fuzzy semi δ -pre irresolute mappings in intuitionistic fuzzy topological spaces. We investigate some of their properties and obtain several preservation properties and characterizations.

Keywords: intuitionistic fuzzy set; intuitionistic fuzzy topology; intuitionistic fuzzy semi δ -pre irresolute mappings.

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1. INTRODUCTION

The concept of fuzzy sets was introduced by Zadeh in his classic paper [11]. Using the concept of fuzzy set Chang [2] introduced the fuzzy topological spaces. Atanassov [1] introduced the notion of intuitionistic fuzzy sets. Coker [4] defined the intuitionistic fuzzy topological spaces. This approach provided a wide field for investigation in the area of fuzzy topology and its applications. In the recent past many researchers such as Coker [5], Joen [6] and Lupianez [8] studied various topological concepts in intuitionistic fuzzy topology. Recently Thakur, Rathor and Bajpai [9] introduced the concepts of Intuitionistic fuzzy semi δ -preopen sets and

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Intuitionistic fuzzy semi δ -precontinuity in Intuitionistic fuzzy topology. The present paper introduces the concept of Intuitionistic fuzzy semi δ -pre irresolute mappings and studied some of their properties in Intuitionistic fuzzy topological spaces.

2. PRELIMINARIES

Let X be a nonempty fixed set and I the closed interval $[0, 1]$. An intuitionistic fuzzy set A is an object having the form $A = \{ \langle x, \mu_A(x), \nu_A(x) \rangle : x \in X \}$ where the functions $\mu_A : X \rightarrow I$ and $\nu_A : X \rightarrow I$ denote the degree of membership namely $\mu_A(x)$ and the degree of nonmembership (namely $\nu_A(x)$) of each element $x \in X$ to the set A , respectively, and $0 \leq \mu_A(x) + \nu_A(x) \leq 1$ for each $x \in X$. For the basic properties of Intuitionistic fuzzy sets and Intuitionistic fuzzy points, the researchers should refer ([1, 8]. An intuitionistic fuzzy topology on a nonempty set X is a family τ of intuitionistic fuzzy sets in X , which contains $\tilde{0}$ and $\tilde{1}$ and closed with respect to any union and finite intersection. The members of τ are called intuitionistic fuzzy open sets and their complements are called intuitionistic fuzzy closed. The union of all intuitionistic fuzzy open subsets of A is called the interior of A . It is denoted by $int(A)$. The intersection of all intuitionistic fuzzy closed sets which contains A is called closure of A . It is denoted by $cl(A)$. An intuitionistic fuzzy set A of an intuitionistic fuzzy topological space (X, τ) is called intuitionistic fuzzy regular open [3] if $A = int(cl(A))$. The complement of an intuitionistic fuzzy regular open set is called intuitionistic fuzzy regular closed. Every Intuitionistic fuzzy regular open (resp. Intuitionistic fuzzy regular closed) set is Intuitionistic fuzzy open (resp. Intuitionistic fuzzy closed) but the converse may not be true [3].

The δ -interior (denoted by δint) [10] of an intuitionistic fuzzy set A of an intuitionistic fuzzy topological space (X, τ) is the union of all intuitionistic fuzzy regular open sets contained in A . The δ -closure (denoted by δcl) [10] of an intuitionistic fuzzy set A of an intuitionistic fuzzy topological space (X, τ) is the intersection of all intuitionistic fuzzy regular closed sets containing A .

Definition 2.1. An intuitionistic fuzzy set A of an intuitionistic fuzzy topological space (X, τ) is called:

- (a). intuitionistic fuzzy semi preopen if there exists an intuitionistic fuzzy preopen set O in X such that $O \subseteq A \subseteq cl(O)$ [7].
- (b). intuitionistic fuzzy δ -preopen if $A \subseteq int(\delta cl(A))$ [10].
- (c). intuitionistic fuzzy semi δ -preopen if there exists an intuitionistic fuzzy δ -preopen set O in X such that $O \subseteq A \subseteq \delta cl(O)$ [9].

The family of all intuitionistic fuzzy semi preopen (resp. intuitionistic fuzzy δ -preopen, intuitionistic fuzzy semi δ -preopen) sets of an intuitionistic fuzzy topological space X is denoted by $IFSPO(X)$ (resp. $IF\delta PO(X), IFS\delta PO(X)$).

Definition 2.2. [9] An intuitionistic fuzzy set A in an intuitionistic fuzzy topological space (X, τ) is called intuitionistic fuzzy semi preclosed (resp. intuitionistic fuzzy δ -preclosed, intuitionistic fuzzy semi δ -preclosed) if $A^C \in IFSPO(X)$ (resp. $IF\delta PO(X), IFS\delta PO(X)$).

Remark 2.1. [9] Every Intuitionistic fuzzy semi preopen (resp. intuitionistic fuzzy δ -preopen) set is intuitionistic fuzzy semi δ -preopen. But the separate converse may not be true.

Definition 2.3. [9] Let (X, τ) be an Intuitionistic fuzzy topological space and A be an intuitionistic fuzzy set of X . Then the intuitionistic fuzzy semi δ -preinterior (denoted by $s\delta pint$) and intuitionistic fuzzy semi δ -preclosure (denoted by $s\delta pcl$) of A respectively defined as follows:
 $s\delta pint(A) = \cup\{O : O \subseteq A; O \in IFS\delta PO(X)\},$
 $s\delta pcl(A) = \cap\{O : O \supseteq A; O \in IFS\delta PC(X)\}.$

Definition 2.4. [9] Let A be an intuitionistic fuzzy set A of an intuitionistic fuzzy topological space (X, τ) and $x_{(\alpha, \beta)}$ be an intuitionistic fuzzy point of X . A is called:

- (a). intuitionistic fuzzy semi δ -pre neighborhood of $x_{(\alpha, \beta)}$ if there exists an intuitionistic fuzzy set $O \in IFS\delta PO(X)$ such that $x_{(\alpha, \beta)} \in O \subseteq A$.
- (b). intuitionistic fuzzy semi δ -pre Q -neighborhood of $x_{(\alpha, \beta)}$ if there exists an intuitionistic fuzzy set $O \in IFS\delta PO(X)$ such that $x_{(\alpha, \beta)q} O \subseteq A$.

Definition 2.5. [3, 9] A mapping $f : (X, \tau) \rightarrow (Y, \sigma)$ is called:

- (a). intuitionistic fuzzy continuous if $f^{-1}(A)$ is intuitionistic fuzzy open set in X for each intuitionistic fuzzy open set A of Y .

- (b). intuitionistic fuzzy semi δ -pre continuous if $f^{-1}(A) \in IFS\delta PO(X)$ for every intuitionistic fuzzy open set A of Y .

3. INTUITIONISTIC FUZZY SEMI δ -PRE IRRESOLUTE MAPPINGS

In this section, we introduce the concept of intuitionistic fuzzy semi δ -pre irresolute mappings and study some of their properties in intuitionistic fuzzy topological spaces.

Definition 3.1. A mapping f from an intuitionistic fuzzy topological space (X, τ) to another intuitionistic fuzzy topological space (Y, σ) is said to be intuitionistic fuzzy semi δ -pre irresolute if $f^{-1}(A) \in IFS\delta PO(X)$ for every intuitionistic fuzzy set $A \in IFS\delta PO(Y)$.

Remark 3.1. Every intuitionistic fuzzy semi δ -pre irresolute mappings is intuitionistic fuzzy semi δ -pre continuous but the converse may not be true.

Example 3.1. Let $X = \{a, b\}$, $Y = \{p, q\}$ and intuitionistic fuzzy sets U defined as follows:

$$U = \{ \langle a, 0.5, 0.5 \rangle, \langle b, 0.4, 0.6 \rangle \}$$

let $\tau = \{ \tilde{0}, U, \tilde{1} \}$ and $\sigma = \{ \tilde{0}, \tilde{1} \}$ be intuitionistic fuzzy topologies on X and Y respectively. Then the mapping $f : (X, \tau) \rightarrow (Y, \sigma)$ defined by $f(a) = p$ and $f(b) = q$ is intuitionistic fuzzy semi δ -precontinuous and hence intuitionistic fuzzy continuous but not intuitionistic fuzzy semi δ -preirresolute.

Consider the following example:

Example 3.2. Let $X = \{a, b\}$, $Y = \{p, q\}$ and intuitionistic fuzzy sets V defined as follows:

$$V = \{ \langle a, 0.4, 0.6 \rangle, \langle b, 0.5, 0.5 \rangle \}$$

let $\tau = \{ \tilde{0}, \tilde{1} \}$ and $\sigma = \{ \tilde{0}, V, \tilde{1} \}$ be intuitionistic fuzzy topologies on X and Y respectively. Then the mapping $g : (X, \tau) \rightarrow (Y, \sigma)$ defined by $g(a) = p$ and $g(b) = q$ is intuitionistic fuzzy semi δ -preirresolute but not intuitionistic fuzzy continuous.

Remark 3.2. Example (3.1) and Example (3.2) shows that the concepts of intuitionistic fuzzy semi δ -preirresolute and intuitionistic fuzzy continuous mappings are independent.

Theorem 3.1. *Let $f : (X, \tau) \rightarrow (Y, \sigma)$ be a mapping then the following statements are equivalent:*

- (a). *f is intuitionistic fuzzy semi δ -preirresolute.*
- (b). *If $f^{-1}(A) \in IFS\delta PC(X)$ for every intuitionistic fuzzy set $A \in IFS\delta PC(Y)$.*
- (c). *for every intuitionistic fuzzy point $x_{(\alpha,\beta)}$ in X and every intuitionistic fuzzy set $A \in IFS\delta PO(Y)$ such that $f(x_{(\alpha,\beta)}) \in A$ there is an intuitionistic fuzzy set $O \in IFS\delta PO(X)$ such that $x_{(\alpha,\beta)} \in O$ and $f(O) \subseteq A$.*
- (d). *for every intuitionistic fuzzy point $x_{(\alpha,\beta)}$ of X and every intuitionistic fuzzy semi δ -pre neighborhood A of $f(x_{(\alpha,\beta)})$, $f^{-1}(A)$ is an intuitionistic fuzzy semi δ -pre neighborhood of $x_{(\alpha,\beta)}$.*
- (e). *for every intuitionistic fuzzy point $x_{(\alpha,\beta)}$ of X and every intuitionistic fuzzy semi δ -pre neighborhood A of $f(x_{(\alpha,\beta)})$, there is an intuitionistic fuzzy semi δ -pre neighborhood U of $x_{(\alpha,\beta)}$ such that $f(U) \subseteq A$.*
- (f). *for every intuitionistic fuzzy point $x_{(\alpha,\beta)}$ of X and every intuitionistic fuzzy set $A \in IFS\delta PO(Y)$ such that $f(x_{(\alpha,\beta)}) \in A$, there is an intuitionistic fuzzy set $O \in IFS\delta PO(X)$ such that $x_{(\alpha,\beta)} \in O$ and $f(O) \subseteq A$.*
- (g). *for every intuitionistic fuzzy point $x_{(\alpha,\beta)}$ of X and every intuitionistic fuzzy semi δ -pre Q -neighborhood A of $f(x_{(\alpha,\beta)})$, $f^{-1}(A)$ is an intuitionistic fuzzy semi δ -pre Q -neighborhood of $x_{(\alpha,\beta)}$.*
- (h). *for every intuitionistic fuzzy point $x_{(\alpha,\beta)}$ of X and every intuitionistic fuzzy semi δ -pre Q -neighborhood A of $f(x_{(\alpha,\beta)})$, there is an intuitionistic fuzzy semi pre Q -neighborhood U of $x_{(\alpha,\beta)}$ such that $f(U) \subseteq A$.*
- (i). *$f(s\delta pcl(A)) \subseteq s\delta pcl(f(A))$, for every intuitionistic fuzzy set A of X .*
- (j). *$s\delta pcl(f^{-1}(O)) \subseteq f^{-1}(s\delta pcl(O))$, for every intuitionistic fuzzy set O of Y .*
- (k). *$f^{-1}(s\delta pint(O)) \subseteq s\delta pint(f^{-1}(O))$, for every intuitionistic fuzzy set O of Y .*

Proof. (a) \Leftrightarrow (b) Obvious.

(a) \Rightarrow (c) Let $x_{(\alpha,\beta)}$ be an intuitionistic fuzzy point of X and $A \in IFS\delta PO(Y)$ such that $f(x_{(\alpha,\beta)}) \in A$. Put $O = f^{-1}(A)$, then by (a), $O \in IFS\delta PO(X)$ such that $x_{(\alpha,\beta)} \in O$ and $f(O) \subseteq A$.

(c) \Rightarrow (a) Let $A \in IFS\delta PO(Y)$ and $x_{(\alpha,\beta)} \in f^{-1}(A)$. Then $f(x_{(\alpha,\beta)}) \in A$. Now by (c) there is an intuitionistic fuzzy set $O \in IFS\delta PO(X)$ such that $x_{(\alpha,\beta)} \in O$ and $f(O) \subseteq A$. Then $x_{(\alpha,\beta)} \in O \subseteq f^{-1}(A)$. Hence $f^{-1}(A) \in IFS\delta PO(X)$.

(a) \Rightarrow (d) Let $x_{(\alpha,\beta)}$ be an intuitionistic fuzzy point of X and A be a semi neighborhood of $f(x_{(\alpha,\beta)})$. Then there is an intuitionistic fuzzy set $U \in IFS\delta PO(X)$ such that $f(x_{(\alpha,\beta)}) \in U \subseteq A$. Now $F^{-1}(U) \in IFS\delta PO(X)$ and $f^{-1}(U) \subseteq f^{-1}(A)$. Thus $f^{-1}(A)$ is an intuitionistic fuzzy semi δ -pre neighborhood of $x_{(\alpha,\beta)}$ in X .

(d) \Rightarrow (e) Let $x_{(\alpha,\beta)}$ be an intuitionistic fuzzy point of X and A be a semi δ -pre neighborhood of $f(x_{(\alpha,\beta)})$. Then $U = f^{-1}(A)$ is an intuitionistic fuzzy semi δ -pre neighborhood of $x_{(\alpha,\beta)}$ and $f(U) = f(f^{-1}(A)) \subseteq A$.

(e) \Rightarrow (c) Let $x_{(\alpha,\beta)}$ be an intuitionistic fuzzy point of X and $A \in IFS\delta PO(Y)$ such that $f(x_{(\alpha,\beta)}) \in A$. So there is intuitionistic fuzzy semi δ -pre neighborhood U of $x_{(\alpha,\beta)}$ in X such that $x_{(\alpha,\beta)} \in U$ and $f(U) \subseteq A$. Hence there is an intuitionistic fuzzy set $O \in IFS\delta PO(X)$ such that $x_{(\alpha,\beta)} \in O \subseteq U$ and so $f(O) \subseteq f(U) \subseteq A$.

(a) \Rightarrow (f) Let $x_{(\alpha,\beta)}$ be an intuitionistic fuzzy point of X and $A \in IFS\delta PO(Y)$ such that $f(x_{(\alpha,\beta)})_q \in A$. Let $O = f^{-1}(A)$. Then $O \in IFS\delta PO(X)$, $x_{(\alpha,\beta)}_q \in O$ and $f(O) = f(f^{-1}(A)) \subseteq A$.

(f) \Rightarrow (a) Let $A \in IFS\delta PO(Y)$ and $x_{(\alpha,\beta)} \in f^{-1}(A)$ clearly $f(x_{(\alpha,\beta)}) \in A$, choose the intuitionistic fuzzy point $x_{(\alpha,\beta)}^c$ defined as

$$(1) \quad x_{(\alpha,\beta)}^c(z) = \begin{cases} (\beta, \alpha) & \text{if } z = x \\ (1, 0) & \text{if } z \neq x \end{cases}$$

Then $f(x_{(\alpha,\beta)}^c)_q \in A$ and so by (f), there exists an intuitionistic fuzzy set $O \in IFS\delta PO(X)$, such that $x_{(\alpha,\beta)}^c \in O$ and $f(O) \subseteq A$. Now $x_{(\alpha,\beta)}^c \in O$ implies $x_{(\alpha,\beta)} \in O$. Thus $x_{(\alpha,\beta)} \in f^{-1}(A)$. Hence

$f^{-1}(A) \in IFS\delta PO(X)$.

(f) \Rightarrow (g) Let $x_{(\alpha,\beta)}$ be an intuitionistic fuzzy point of X and A be semi δ - Q -neighborhood of $f(x_{(\alpha,\beta)})$. Then there is an intuitionistic fuzzy open set $A_1 \in IFS\delta PO(Y)$ such that $f(x_{(\alpha,\beta)})_q \subseteq A_1 \subseteq A$. By hypothesis there is an intuitionistic fuzzy set $O \in IFS\delta PO(X)$ such that $x_{(\alpha,\beta)}_q O$ and $f(O) \subseteq A_1$. Thus $x_{(\alpha,\beta)}_q O \subseteq f^{-1}(A_1) \subseteq f^{-1}(A)$. Hence $f^{-1}(A)$ is an intuitionistic fuzzy semi δ -pre Q -neighborhood of $x_{(\alpha,\beta)}$.

(g) \Rightarrow (h) Let $x_{(\alpha,\beta)}$ be an intuitionistic fuzzy point of X and A be a semi δ -pre- Q -neighborhood of $f(x_{(\alpha,\beta)})$. Then $U = f^{-1}(A)$ is an intuitionistic fuzzy semi δ -pre- Q -neighborhood of $x_{(\alpha,\beta)}$ and $f(U) = f(f^{-1}(A)) \subseteq A$.

(h) \Rightarrow (f) Let $x_{(\alpha,\beta)}$ be an intuitionistic fuzzy point of X and $A \in IFS\delta PO(Y)$ such that $f(x_{(\alpha,\beta)})_q A$. Then A is intuitionistic fuzzy semi δ -pre- Q -neighborhood of $f(x_{(\alpha,\beta)})$. So there is an intuitionistic fuzzy semi δ -pre Q -neighborhood U of $x_{(\alpha,\beta)}$ such that $f(U) \subseteq A$. Now U being an intuitionistic fuzzy semi δ -pre Q -neighborhood of $x_{(\alpha,\beta)}$. Then there exists an intuitionistic fuzzy set $O \in IFS\delta PO(X)$ such that $x_{(\alpha,\beta)}_q O \subseteq U$. Hence $x_{(\alpha,\beta)}_q O$ and $f(O) \subseteq f(U) \subseteq A$.

(b) \Rightarrow (i) Let A be an intuitionistic fuzzy set of X . Since $A = f^{-1}(f(A))$, we have $A \subseteq f^{-1}(s\delta pcl(f^{-1}(A)))$. Now $s\delta pcl(f(A)) \in IFS\delta PC(Y)$ and hence $f^{-1}(s\delta pcl(f(A))) \in IFS\delta PC(X)$. Therefore $s\delta pcl(A) \subseteq f^{-1}(s\delta pcl(f(A)))$ and $f(s\delta pcl(A)) \subseteq f(f^{-1}(s\delta pcl(f(A)))) \subseteq s\delta pcl(f(A))$.

(i) \Rightarrow (b) Let $A \in IFS\delta PC(Y)$ then $f(s\delta pcl(f^{-1}(A))) \subseteq s\delta pcl(f(f^{-1}(A))) \subseteq s\delta pcl(A) = A$. Hence $s\delta pcl(f^{-1}(A)) \subseteq f^{-1}(A)$ and so $f^{-1}(A) \in IFS\delta PC(X)$.

(i) \Rightarrow (j) Let O be any intuitionistic fuzzy set of Y , then $f^{-1}(O)$ is an intuitionistic fuzzy set of X . Therefore by hypothesis (i), $f(s\delta pcl(f^{-1}(O))) \subseteq s\delta pcl(f(f^{-1}(O))) \subseteq s\delta pcl(O)$. Hence $s\delta pcl(f^{-1}(O)) \subseteq f^{-1}(s\delta pcl(O))$.

(j) \Rightarrow (i) Let A be any intuitionistic fuzzy set of X , then $f^{-1}(A)$ is an intuitionistic fuzzy set of Y and by (j), $s\delta pcl(f^{-1}(f(A))) \subseteq f^{-1}(s\delta pcl(f(A)))$. Hence $f(s\delta pcl(A)) \subseteq s\delta pcl(f(A))$.

(a) \Rightarrow (k) Let O be any intuitionistic fuzzy set of Y , then $s\delta pint(O) \in IFS\delta PO(Y)$ and $f^{-1}(s\delta pint(O)) \in IFS\delta PO(X)$. Since $f^{-1}(s\delta pint(O)) \subseteq f^{-1}(O)$, then $f^{-1}(s\delta pint(O)) \subseteq s\delta pint(f^{-1}(O))$.

(k) \Rightarrow (a) Let $O \in IFS\delta PO(Y)$, then $s\delta pint(O) = O$ and $f^{-1}(O) \subseteq s\delta pint(f^{-1}(O))$. Thus $f^{-1}(O) = s\delta pint(f^{-1}(O))$ and $f^{-1}(O) \in IFS\delta PO(X)$. Hence f is intuitionistic fuzzy semi δ -preirresolute. □

Definition 3.2. A mapping $f : (X, \tau) \rightarrow (Y, \sigma)$ is called intuitionistic fuzzy R -open if the image of every intuitionistic fuzzy open set of X is intuitionistic fuzzy δ -open in Y .

Theorem 3.2. *If $f : (X, \tau) \rightarrow (Y, \sigma)$ is intuitionistic fuzzy δ -almost continuous and intuitionistic fuzzy R -open mapping, then f is intuitionistic fuzzy semi δ -preirresolute.*

Proof. Let $A \in IFS\delta PO(Y)$. Then there exist an intuitionistic fuzzy set $O \in IF\delta PO(X)$ such that $O \subseteq A \subseteq \delta cl(O)$, therefore $f^{-1}(O) \subseteq f^{-1}(A) \subseteq f^{-1}(\delta cl(O)) \subseteq cl(f^{-1}(O))$ because f is intuitionistic fuzzy R -open. Since f is intuitionistic fuzzy δ -almost continuous and intuitionistic fuzzy R -open, $f^{-1}(O) \in IF\delta PO(X)$. Hence $f^{-1}(A) \in IFS\delta PO(X)$. □

Theorem 3.3. *Let $f : (X, \tau) \rightarrow (Y, \sigma)$ and $g : (Y, \sigma) \rightarrow (Z, \eta)$ be intuitionistic fuzzy semi δ -preirresolute mappings then gof is intuitionistic fuzzy semi δ -preirresolute.*

Proof. Let $A \in IFS\delta PO(Z)$. Since g is intuitionistic fuzzy semi δ -preirresolute, $g^{-1}(A) \in IFS\delta PO(Y)$. Therefore $(gof)^{-1}(A) = f^{-1}(g^{-1}(A)) \in IFS\delta PO(X)$, because f is intuitionistic fuzzy semi δ -preirresolute.

Hence gof is intuitionistic fuzzy semi δ -preirresolute. □

Theorem 3.4. *Let $f : (X, \tau) \rightarrow (Y, \sigma)$ is intuitionistic fuzzy semi δ -preirresolute and $g : (Y, \sigma) \rightarrow (Z, \eta)$ is intuitionistic fuzzy semi δ -precontinuous mapping, then gof is intuitionistic fuzzy semi δ -precontinuous.*

Proof. Let O be any intuitionistic fuzzy open set of Z . Since g is intuitionistic fuzzy semi δ -precontinuous $g^{-1}(O) \in IFS\delta PO(Y)$. therefore $(gof)^{-1}(O) = f^{-1}(g^{-1}(O)) \in IFS\delta PO(X)$ because f is intuitionistic fuzzy semi δ -preirresolute.

Hence gof is intuitionistic fuzzy semi δ -precontinuous. \square

4. CONCLUSION

In this paper, a new class of mappings called Intuitionistic fuzzy semi δ -pre irresolute mappings have been introduced, it is shown by examples that the concepts of Intuitionistic fuzzy semi δ -pre irresolute mappings is stronger than the Intuitionistic fuzzy semi δ -pre continuous mappings and independent to the Intuitionistic fuzzy continuous mappings. Several characterizations and properties of these class of Intuitionistic fuzzy mappings have been studied.

CONFLICT OF INTERESTS

The author(s) declare that there is no conflict of interests.

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