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WEEKLY GENERALIZED SEMI-PRE CONTINUOUS MAPPINGS IN INTUITIONISTIC FUZZY TOPOLOGICAL SPACES

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ABSTRACT

In this paper we introduce intuitionistic fuzzy weakly generalized semi-pre continuous mappings. We investigate some of its properties. Also we provide the relation between intuitionistic fuzzy weekly generalized semi-pre continuous mappings and other intuitionistic fuzzy continuous mappings.

Key words and phrases: *Intuitionistic fuzzy topology, intuitionistic fuzzy weekly generalized semi-pre continuous mappings.*

1. INTRODUCTION

After the introduction of fuzzy sets by Zadeh [10], there have been a number of generalizations of this fundamental concept. The notion of intuitionistic fuzzy sets introduced by Atanassov [1] is one among them. Using the notion of intuitionistic fuzzy sets, Coker [2] introduced the notion of intuitionistic fuzzy topological spaces. Intuitionistic fuzzy semi-pre continuous mappings in intuitionistic fuzzy topological spaces are introduced by Young Bae Jun and Seok-Zun Song [9]. R. Santhi and D. Jayanthi [6] introduced the notion of intuitionistic fuzzy generalized semi-pre continuous mappings and intuitionistic fuzzy generalized semi-pre irresolute mappings. In this paper we introduce intuitionistic fuzzy weekly generalized semi-pre continuous mappings. We investigate some of its properties.

2. PRELIMINARIES

Definition 2.1: [1] An intuitionistic fuzzy set (IFS in short) A in X is an object having the form

$$A = \{\langle x, \mu_A(x), \nu_A(x) \rangle / x \in X\}$$

where the functions $\mu_A: X \to [0,1]$ and $\nu_A: X \to [0,1]$ denote the degree of membership (namely $\mu_A(x)$) and the degree of non -membership (namely $\nu_A(x)$) of each element $x \in X$ to the set A, respectively, and $0 \le \mu_A(x) + \nu_A(x) \le 1$ for each $x \in X$. Denote by IFS (X), the set of all intuitionistic fuzzy sets in X.

Definition 2.2: [1] Let A and B be IFSs of the form $A = \{\langle x, \mu_A(x), \nu_A(x) \rangle / x \in X\}$ and $B = \{\langle x, \mu_B(x), \nu_B(x)\rangle / x \in X\}$. Then

(a) $A \subseteq B$ if and only if $\mu_A(x) \le \mu_B(x)$ and $\nu_A(x) \ge \nu_B(x)$ for all $x \in X$
(b) $A = B$ if and only if $A \subseteq B$ and $B \subseteq A$
(c) $A^c = \{\langle x, \nu_A(x), \mu_A(x) \rangle / x \in X\}$
(d) $A \cap B = \{\langle x, \mu_A(x) \wedge \mu_B(x), \nu_A(x) \vee \nu_B(x) \rangle / x \in X\}$
(e) $A \cup B = \{\langle x, \mu_A(x) \vee \mu_B(x), \nu_A(x) \wedge \nu_B(x) \rangle / x \in X\}$

For the sake of simplicity, we shall use the notation $A = \langle x, \mu_A, \nu_A\rangle$ instead of $A = \{\langle x, \mu_A(x), \nu_A(x) \rangle / x \in X\}$.

The intuitionistic fuzzy sets $0_\sim = \{\langle x, 0, 1 \rangle / x \in X\}$ and $1_\sim = \{\langle x, 1, 0 \rangle / x \in X\}$ are respectively the empty set and the whole set of X.

Definition 2.3: [2] An intuitionistic fuzzy topology (IFT for short) on X is a family τ of IFSs in X satisfying the following axioms.

(i) $0_\sim, 1_\sim \in \tau$
(ii) $G_1 \cap G_2 \in \tau$ for any $G_1, G_2 \in \tau$
(iii) $\cup G_i \in \tau$ for any family $\{G_i / i \in J\} \subseteq \tau$.

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In this case the pair (X, τ) is called an intuitionistic fuzzy topological space (IFTS in short) and any IFS in τ is known as an intuitionistic fuzzy open set (IFOS for short) in X. The complement A^c of an IFOS A in IFTS (X, τ) is called an intuitionistic fuzzy closed set (IFCS for short) in X.

Definition 2.4: [4] Let (X, τ) be an IFTS and $A = \langle x, \mu_A, \nu_A \rangle$ be an IFS in X. Then the intuitionistic fuzzy interior and intuitionistic fuzzy closure are defined by

int (A) = $\cup$ {G / G is an intuitionistic fuzzy open set in X and $G \subseteq A$}
cl (A) = $\cap$ {K / K is an intuitionistic fuzzy closed set in X and $A \subseteq K$}

Note that for any IFS A in (X, τ), we have $cl(A^c) = [int(A)]^c$ and $int(A^c) = [cl(A)]^c$ [12].

Definition 2.5:[4] An IFS $A = \langle x, \mu_A, \nu_A \rangle$ in an IFTS (X, τ) is said to be an

(i) *intuitionistic fuzzy semi closed set* (IFSCS for short) if $int(cl(A)) \subseteq A$
(ii) *intuitionistic fuzzy pre closed set* (IFPCS for short) if $cl(int(A)) \subseteq A$
(iii) *intuitionistic fuzzy α closed set* (IFαCS for short) if $cl(int(cl(A)) \subseteq A$.

The respective complements of the above IFCSs are called their respective IFOSs. The family of all IFSCSs, IFPCSs, and IFαCSs (respectively intuitionistic fuzzy semi open sets(IFSOSs), intuitionistic fuzzy pre open sets(IFPOSs) and intuitionistic fuzzy α open sets(IFαOSs) of an IFTS (X, τ) are respectively denoted by IFSC(X), IFPC(X) and IFαC(X) (respectively IFSO(X), IFPO(X) and IFαO(X)).

Definition 2.6: [8] An IFS A is an intuitionistic fuzzy regular open set if $A = int(cl(A))$.

Definition 2.7: [9] An IFS $A = \langle x, \mu_A, \nu_A \rangle$ in an IFTS (X, τ) is said to be an intuitionistic fuzzy semi-pre open set (IFSPOS for short) if there exists an intuitionistic fuzzy pre open set B such that $B \subseteq A \subseteq cl(B)$.

Note that an IFS A is an IFSPOS if and only if $A \subseteq cl(int(cl(A)))$ [5].

Definition 2.8: [8] An IFS A is an intuitionistic fuzzy generalized closed set (IFGCS for short) if $cl(A) \subseteq U$ whenever $A \subseteq U$ and U is an IFOS.

Definition 2.9: [5] An IFS A in an IFTS (X, τ) is said to be an intuitionistic fuzzy generalized semi-pre closed set (IFGSPCS for short) if $spcl(A) \subseteq U$ whenever $A \subseteq U$ and U is an IFOS in (X, τ). The complement A^c of an IFGSPCS A in an IFTS (X, τ) is called an intuitionistic fuzzy generalized open set (IFGSPOS for short) in X.

Definition 2.10: Let A be an IFS in an IFTS (X, τ). Then the generalized semi-pre interior and the generalized semi-pre closure of A are defined by
gspint (A) = $\cup$ {G / G is an IFGSPOS in X and $G \subseteq A$}
gspcl (A) = $\cap$ {K / K is an IFGSPCS in X and $A \subseteq K$}

Note that for any IFS A in (X, τ), we have $gspcl(A^c) = [gspint(A)]^c$ and $gspint(A^c) = [gspcl(A)]^c$.

Remark 2.11: If an IFS A in an IFTS (X,τ) is an IFGSPCS in X, then gspcl(A) = A. But the converse may not be true in general, since intersection does not exist in IFGSPCSs [5]

Remark 2.12: If an IFS A in an IFTS (X,τ) is an IFGSPOS in X, then gspint (A) = A. But the converse may not be true in general, since union does not exist in IFGSPOSs [5]

Definition 2.13: [4] Let f be a mapping from an IFTS (X, τ) into an IFTS (Y,σ). Then f is said to be an intuitionistic fuzzy continuous mapping (IFCts.M for short) if $f^{-1}(B) \in IFO(X)$ for every $B \in \sigma$

Definition 2.14: [4] Let f be a mapping from an IFTS (X, τ) into an IFTS (Y,σ). Then f is said to be an
(i) intuitionistic fuzzy semi continuous mapping (IFSCts. for short) if $f^{-1}(B) \in IFSO(X)$ for every $B \in \sigma$
(ii) intuitionistic fuzzy α- continuous mapping (IFαCts. for short) if $f^{-1}(B) \in IF\alpha O(X)$ for every $B \in \sigma$
(iii) intuitionistic fuzzy pre continuous mapping (IFPCts. for short) if $f^{-1}(B) \in IFPO(X)$ for every $B \in \sigma$

Definition 2.15: [8] Let f be a mapping from an IFTS (X, τ) into an IFTS (Y,σ). Then f is said to be an intuitionistic fuzzy generalized continuous mapping (IFGCts. for short) if $f^{-1}(B) \in IFGC(X)$ for every IFCS B in Y.

Definition 2.16: [9] Let f be a mapping from an IFTS (X, τ) into an IFTS (Y,σ). Then f is said to be an intuitionistic fuzzy semi-pre continuous mapping (IFSPCts. for short) if $f^{-1}(B) \in$ IFSPO(X) for every $B \in \sigma$

Definition 2.17:[6] A mapping f: $(X, \tau) \to (Y,\sigma)$ is called an *intuitionistic fuzzy generalized semi-pre continuous* mapping (IFGSPCts. for short) if $f^{-1}(V)$ is an IFGSPCS in (X, τ) for every IFCS V of (Y, σ).

Definition 2.18:[7] A mapping f: $(X, \tau) \to (Y,\sigma)$ is called an *intuitionistic fuzzy completely generalized semi-pre continuous* mapping (IFcomGSPCts. for short) if $f^{-1}(V)$ is an IFRCS in (X, τ) for every IFGSPCS V of (Y, σ).

3. INTUITIONISTIC FUZZY WEEKLY GENERALIZED SEMI-PRE CONTINUOUS MAPPINGS

In this section we introduce intuitionistic fuzzy weekly generalized semi-pre continuous mappings and study some of its properties

Definition 3.1: A mapping f: $X \to Y$ is said to be an intuitionistic fuzzy weekly generalized semi-pre continuous mapping (IFWGSPCts.M for short) if $f^{-1}(V) \subseteq gspint(f^{-1}(cl(V)))$ for each IFOS V in Y.

Example 3.2: Let X = {a, b}, Y = {u, v} and $G_1 = \langle x, (0.5_a, 0.6_b), (0.2_a, 0_b) \rangle$, $G_2 = \langle x, (0.4_a, 0.1_b), (0.2_a, 0.1_b)\rangle$, $G_3 = \langle y, (0.2_u, 0.2_v), (0.4_u, 0.4_v)\rangle$ and $G_4 = \langle y, (0.2_u, 0_v), (0.5_u, 0.4_v)\rangle$. Then $\tau = \{0_\sim, G_1, G_2, 1_\sim\}$ and $\sigma = \{0_\sim, G_3, G_4, 1_\sim\}$ are IFTs on X and Y respectively. Define a mapping f: $(X, \tau) \to (Y,\sigma)$ by f(a) = u and f(b) = v. Then f is an IFWGSPCts.M.

Theorem 3.3: Every IFGSPCts.M is an IFWGSPCts.M but not conversely.

Proof: Let f: $X \to Y$ be an IFGSPCts.M. Let V be any IFOS in Y. Then by hypothesis, $f^{-1}(V)$ is an IFGSPOS in X. Therefore $gspint(f^{-1}(V)) = f^{-1}(V)$. Now $f^{-1}(V) = gspint(f^{-1}(V)) \subseteq gspint(f^{-1}(cl(V)))$. Hence f is an IFWGSPCts.M.

Example 3.4: In Example 4.2, f is an IFWGSPCts.M but not an IFGSPCts.M, since $G_4^c = \langle y, (0.5_u, 0.4_v), (0.2_u, 0_v) \rangle$ is an IFCS in Y but $f^{-1}(G_4^c) = \langle x, (0.5_a, 0.4_b), (0.2_a, 0_b)\rangle$ is not an IFGSPCS, since $f^{-1}(G_4^c) \subseteq G_1$ but $spcl(f^{-1}(G_4^c)) = 1_\sim \subseteq G_1$.

Theorem 3.5: Every IFcomGSPCts.M is an IFWGSPCts.M but not conversely.

Proof: Let f: $X \to Y$ be an IFcomGSPCts.M. Let V be any IFOS in Y. Since every IFOS is an IFGSPOS, V is an IFGSPOS. Then by hypothesis, $f^{-1}(V)$ is an IFROS in X.

Therefore $gspint(f^{-1}(V)) = f^{-1}(V)$. Now $f^{-1}(V) = gspint(f^{-1}(V)) \subseteq gspint(f^{-1}(cl(V)))$. Hence f is an IFWGSPCts.M.

Example 3.6: In Example 4.2, f is an IFWGSPCts.M but not an IFcomGSPCts.M, since $G_4 = \langle y, (0.2_u, 0_v), (0.5_u, 0.4_v)\rangle$ is an IFGSPCS in Y but not an IFRCS in X, since $cl(int(G_4)) = 0_\sim \neq G_4$.

Theorem 3.7: Every IFCts.M is an IFWGSPCts.M but not conversely.

Proof: Let f: $X \to Y$ be an IFCts.M. Since every IFCts.M is an IFGSPCts.M, by Theorem 4.3, f is an IFWGSPCts.M.

Example 3.8: In Example 4.2, f is an IFWGSPCts.M but not an IFCts.M, since $G_4^c = \langle y, (0.5_u, 0.4_v), (0.2_u, 0_v) \rangle$ is an IFCS in Y but $f^{-1}(G_4^c) = \langle x, (0.5_a, 0.4_b), (0.2_a, 0_b)\rangle$ is not an IFCS in X, since $cl(f^{-1}(G_4^c)) = 1_\sim \neq f^{-1}(G_4^c)$.

Theorem 3.9: Every IFSCts.M is an IFWGSPCts.M but not conversely.

Proof: Let f: $X \to Y$ be an IFSCts.M. Since every IFSCts.M is an IFGSPCts.M, by Theorem 4.3, f is an IFWGSPCts.M.

Example 3.10: In Example 4.2, f is an IFWGSPCts.M but not an IFSCts.M, since $G_4^c = \langle y, (0.5_u, 0.4_v), (0.2_u, 0_v)\rangle$ is an IFCS in Y but $f^{-1}(G_4^c) = \langle x, (0.5_a, 0.4_b), (0.2_a, 0_b)\rangle$ is not an IFSCS in X, since $int(cl(f^{-1}(G_4^c))) = 1_\sim \subseteq f^{-1}(G_4^c)$.

Theorem 3.11: Every IFPCts.M is an IFWGSPCts.M but not conversely.

Proof: Let f: $X \to Y$ be an IFPCts.M. Since every IFPCts.M is an IFGSPCts.M, by Theorem 4.3, f is an IFWGSPCts.M.

Example 3.12: Let X = {a, b}, Y = {u, v} and $G_1 = \langle x, (0.5_a, 0.6_b), (0.5_a, 0.4_b)\rangle$, $G_2 = \langle x, (0.4_a, 0.1_b), (0.6_a, 0.7_b)\rangle$, $G_3 = \langle y, (0.6_u, 0.7_v), (0.4_u, 0.2_v)\rangle$. Then $\tau = \{0_\sim, G_1, G_2, 1_\sim\}$and $\sigma = \{0_\sim, G_3, 1_\sim\}$ are IFTs on X and Y respectively. Define a mapping f: (X, τ) $\rightarrow$ (Y,σ) by f(a) = u and f(b) = v. Then f is an IFWGSPCts.M but not an IFPCts.M. Since G_3 is an IFOS in Y but $f^{-1}(G_3) = \langle x, (0.6_a, 0.7_b), (0.4_a, 0.2_b)\rangle \subseteq int(cl(f^{-1}(G_3))) = G_1$ is not an IFPOS.

Theorem 3.13: Every IFSPCts.M is an IFWGSPCts.M but not conversely.

Proof: Let f: X $\rightarrow$ Y be an IFSPCts. M. Since every IFSPCts.M is an IFGSPCts. M, by Theorem 4.3, f is an IFWGSPCts.M.

Example 3.14: Let X = {a, b}, Y = {u, v} and $G_1 = \langle x, (0.6_a, 0.7_b), (0.2_a, 0.3_b)\rangle$, $G_2 = \langle x, (0.2_a, 0.1_b), (0.7_a, 0.8_b)\rangle$, $G_3 = \langle x, (0.5_a, 0.6_b), (0.5_a, 0.4_b)\rangle$, and let $G_4 = \langle y, (0.5_u, 0.3_v), (0.5_u, 0.7_v)\rangle$. Then $\tau = \{0_\sim, G_1, G_2, G_3, 1_\sim\}$ and $\sigma = \{0_\sim, G_4, 1_\sim\}$ are IFTs on X and Y respectively. Define a mapping f: (X, τ) $\rightarrow$ (Y, σ) by f(a) = u and f(b) = v. Then f is an IFWGSPCts.M but not an IFSPCts.M, since G_4 is an IFOS in Y but $f^{-1}(G_4) = \langle x, (0.5_a, 0.3_b), (0.5_a, 0.7_b)\rangle \subseteq cl(int(cl(f^{-1}(G_4)))) = G_1^c$ is not an IFSPOS.

Theorem 3.15: Every IFαCts.M is an IFWGSPCts.M but not conversely.

Proof: Let f: X $\rightarrow$ Y be an IFαCts.M. Since every IFαCts.M is an IFGSPCts.M, by Theorem 4.3, f is an IFWGSPCts.M.

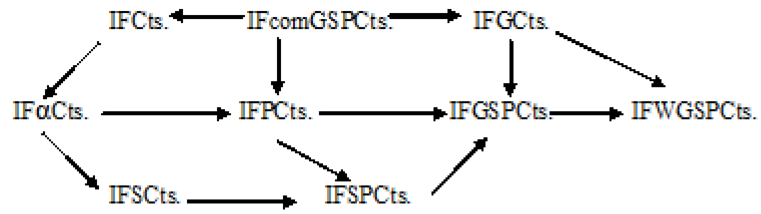
Example 3.16: In Example 4.2, f is an IFWGSPCts.M but not an IFαCts.M, since $G_4^c = \langle y, (0.5_u, 0.4_v), (0.2_u, 0_v)\rangle$ is an IFCS in Y but $f^{-1}(G_4^c) = \langle x, (0.5_a, 0.4_b), (0.2_a, 0_b)\rangle$ is not an IFαCS in X, since $cl(int(cl(f^{-1}(G_4^c)))) = 1_\sim \subseteq f^{-1}(G_4^c)$.

Theorem 3.17: Every IFGCts.M is an IFWGSPCts.M but not conversely.

Proof: Let f: X $\rightarrow$ Y be an IFGCts.M. Since every IFGCts.M is an IFGSPCts.M, by Theorem 4.3, f is an IFWGSPCts.M.

Example 3.18: In Example 4.2, f is an IFWGSPCts.M but not an IFGCts.M, since $G_4^c = \langle y, (0.5_u, 0.4_v), (0.2_u, 0_v)\rangle$ is an IFCS in Y but $f^{-1}(G_4^c) = \langle x, (0.5_a, 0.4_b), (0.2_a, 0_b)\rangle$ is not an IFGCS, since $f^{-1}(G_4^c) \subseteq G_1$ but $cl(f^{-1}(G_4^c)) = 1_\sim \subseteq G_1$.

The relation between various types of intuitionistic fuzzy continuity is given in the following diagram.



The reverse implications are not true in general in the above diagram

Theorem 3.19: For a mapping f: X $\rightarrow$ Y, the following are equivalent
(i) f is an IFWGSPCts.M.
(ii) $f^{-1}(int(A)) \subseteq gspint(f^{-1}(A))$ for each IFCS A in Y
(iii) $f^{-1}(int(cl(A))) \subseteq gspint(f^{-1}(cl(A)))$ for each IFOS A in Y
(iv) $f^{-1}(A) \subseteq gspint(f^{-1}(cl(A)))$ for each IFPOS A in Y
(v) $f^{-1}(A) \subseteq gspint(f^{-1}(cl(A)))$ for each IFαOS A in Y

Proof: (i) $\Rightarrow$ (ii) Let A $\subseteq$ Y be an IFCS. Then int(A) = int(cl(A)), which is an IFROS. Hence int(A) is an IFOS in Y. Therefore by (i) $f^{-1}(int(A)) \subseteq gspint(f^{-1}(cl(A))) = gspint(f^{-1}(A))$, since cl(A) = A. Hence $f^{-1}(int(A)) \subseteq gspint(f^{-1}(A))$.

(ii) $\Rightarrow$ (iii) Let A $\subseteq$ Y be an IFOS. Then int(A) = A. Now cl(A) = cl(int(A)), which is an IFRCS. Therefore cl(A) is an IFCS in Y. By (ii) $f^{-1}(int(cl(A))) \subseteq gspint(f^{-1}(cl(A)))$.

(iii) $\Rightarrow$ (iv) Let A be an IFPOS in Y. Then A $\subseteq$ int(cl(A)). Now $f^{-1}(A) \subseteq f^{-1}(int(cl(A)))$. Since int(cl(A)) is an IFROS, it is an IFOS. Hence (iii) implies $f^{-1}(int(cl(int(cl(A))))) \subseteq gspint(f^{-1}(cl(int(cl(A)))) \subseteq gspint(f^{-1}(cl(A)))$. That is $f^{-1}(int(cl(A))) \subseteq gspint(f^{-1}(cl(A)))$.

Thus $f^{-1}(A) \subseteq \text{gspint}(f^{-1}(\text{cl}(A)))$.

(iv) $\Rightarrow$ (v) is obvious, since every IFαOS is an IFPOS.

(v) $\Rightarrow$ (i) Let $A \subseteq Y$ be an IFOS. Since every IFOS is an IFαOS, A is an IFαOS. Hence by (v), $f^{-1}(A) \subseteq \text{gspint}(f^{-1}(\text{cl}(A)))$. Therefore f is an IFWGSPCts.M.

Theorem 3.20: Let $f: X \to Y$ be a bijective mapping. Then the following are equivalent.

(i) f is an IFWGSPCts.M.
(ii) $\text{gspcl}(f^{-1}(A)) \subseteq f^{-1}(\text{cl}(A))$ for each IFOS A in Y
(iii) $\text{gspcl}(f^{-1}(\text{int}(A))) \subseteq f^{-1}(A)$ for each IFCS A in Y

Proof: (i) $\Rightarrow$ (iii) Let $A \subseteq Y$ be an IFCS. Then A^c is an IFOS in Y. By (i) $f^{-1}(A^c) \subseteq \text{gspint}(f^{-1}(\text{cl}(A^c)))$. This implies $\text{gspcl}(f^{-1}(A)) \subseteq f^{-1}(\text{cl}(A))$.

(iii) $\Rightarrow$ (i) is obvious.

(ii) $\Rightarrow$ (iii) Let $A \subseteq Y$ be an IFCS. Then int(A) is an IFOS in Y. By (ii), $\text{gspcl}(f^{-1}(\text{int}(A))) \subseteq f^{-1}(\text{cl}(\text{int}(A))) \subseteq f^{-1}(\text{cl}(A)) = f^{-1}(A)$, since $\text{cl}(A) = A$. Hence $\text{gspcl}(f^{-1}(\text{int}(A))) \subseteq f^{-1}(A)$.

(iii) $\Rightarrow$ (ii) Let $A \subseteq Y$ be an IFOS, then $\text{int}(A) = A$ and cl(A) is an IFCS. By (iii), $\text{gspcl}(f^{-1}(\text{int}(\text{cl}(A)))) \subseteq f^{-1}(\text{cl}(A))$. Now $\text{gspcl}(f^{-1}(A)) = \text{gspcl}(f^{-1}(\text{int}(A))) \subseteq \text{gspcl}(f^{-1}(\text{int}(\text{cl}(A)))) \subseteq f^{-1}(\text{cl}(A)$. Hence $\text{gspcl}(f^{-1}(A)) \subseteq f^{-1}(\text{cl}(A))$.

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