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Presemi Weakly Closed Set in Intuitionistic Fuzzy Topological Spaces

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Abstract. In this paper, an intuitionistic fuzzy presemi weakly closed set and intuitionistic fuzzy presemi weakly open set are introduced. Some of their properties are studied. Also interrelations of intuitionistic fuzzy presemi weakly closed set and other existing intuitionistic fuzzy closed sets such as intuitionistic fuzzy α closed set, intuitionistic fuzzy regular closed set, intuitionistic fuzzy semi closed, intuitionistic fuzzy semi closed set, intuitionistic fuzzy preclosed set, intuitionistic fuzzy α generalized closed set are discussed**.**

Keywords: Intuitionistic fuzzy presemi weakly closed set, Intuitionistic fuzzy presemi weakly open set.

AMS Mathematics Subject Classification (2010): 54A40, 03E72

1. Introduction

After the introduction of the concept of fuzzy sets by Zadeh [13], several researches were conducted on the generalizations of the notion of fuzzy set. The idea of intuitionistic fuzzy set was first published by Atanassov [2] and many works by the same author and his colleagues appeared in the literature [2, 3, 4]. Coker [5] introduced the notions of an intuitionistic fuzzy topological spaces. Maragathavalli and Kulandaivelu [8] introduced Semi weakly generalized closed set in intuitionistic fuzzy topological space. In this paper, we introduce presemi weakly closed set in intuitionistic fuzzy topological space. We have studied some of the basic properties regarding it.

2. Preliminaries

Definition 2.1. [4] Let X be a non empty fixed set. An intuitionistic fuzzy set (IFS in short) A in X is an object having the form $A = \{\langle x, \mu_A(x), \nu_A(x)\rangle \mid x \in X\}$ where the functions $\mu_A(x): X \to [0,1]$ and $\nu_A(x): X \to [0,1]$ 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 $0 \leq \mu_A(x) + \nu_A(x) \leq 1$ for each $x \in X$. Denote the set of all intuitionistic fuzzy sets in X by IFS(X).

Definition 2.2. [4] Let A and B be IFS's of the forms $A = \{\langle x, \mu_A(x), \nu_A(x)\rangle \mid x \in X\}$ and $B = \{\langle x, \mu_B(x), \nu_B(x)\rangle \mid x \in X\}$. 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) $A^c = \{\langle x, \nu_A(x), \mu_A(x)\rangle \mid x \in X\}$
(d) $A \cap B = \{\langle x, \mu_A(x) \wedge \mu_B(x), \nu_A(x) \vee \nu_B(x)\rangle \mid x \in X\}$
(e) $A \cup B = \{\langle x, \mu_A(x) \vee \mu_B(x), \nu_A(x) \wedge \nu_B(x)\rangle \mid x \in X\}$
For the sake of simplicity, we shall use the notation $A = \langle x, \mu_A, \nu_A \rangle$ instead of $A = \{\langle x, \mu_A(x), \nu_A(x)\rangle \mid x \in X\}$. Also for the sake of simplicity, we shall use the notation $A = \langle x, (\mu_A, \mu_B), (\nu_A, \nu_B) \rangle$ instead of $A = \langle x, \left(\frac{A}{\mu_A}, \frac{B}{\mu_B}\right), \left(\frac{A}{\nu_A}, \frac{B}{\nu_B}\right) \rangle$

Note 2.1.[4] The intuitionistic fuzzy sets $0_\sim = \{\langle x, 0, 1\rangle \mid x \in X\}$ and $1_\sim = \{\langle x, 1, 0\rangle \mid x \in X\}$ are respectively the empty set and the whole set of X.

Definition 2.3. [5] An intuitionistic fuzzy topology (IFT in short) on a non empty X is a family τ of IFS in X satisfying the following axioms:
(a) $0_\sim, 1_\sim \in \tau$
(b) $G_1 \cap G_2 \in \tau$, for any $G_1, G_2 \in \tau$
(c) $\cup G_i \in \tau$ for any arbitrary family $\{G_i \mid i \in J\} \subseteq \tau$
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 an IFTS (X, τ) is called an intuitionistic fuzzy closed set (IFCS for short) in X.

Definition 2.4. [5] 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 an intuitionistic fuzzy closure are defined by
$\text{int}(A) = \cup\{ G \mid G \text{ is an IFOS in X and } G \subseteq A \}$
$\text{cl}(A) = \cap\{ K \mid K \text{ is an IFCS in X and } A \subseteq K \}$.

Result 2.1. [5] Let A and B be any two intuitionistic fuzzy sets of an IFTS (X, τ). Then
(a) A is an IFCS in X $\Leftrightarrow$ $\text{cl}(A) = A$
(b) A is an IFOS in X $\Leftrightarrow$ $\text{int}(A) = A$
(c) $A \subseteq B \Rightarrow \text{int}(A) \subseteq \text{int}(B)$
(d) $A \subseteq B \Rightarrow \text{cl}(A) \subseteq \text{cl}(B)$
(e) $\text{cl}(A^c) = (\text{int}(A))^c$
(d) $\text{int}(A^c) = (\text{cl}(A))^c$.

Definition 2.5. [6] An IFS $A = \{\langle x, \mu_A(x), \nu_A(x)\rangle \mid x \in X\}$ in an IFTS (X, τ) is said to be an
(a) intuitionistic fuzzy semi open set (IFSOS in short) if $A \subseteq \text{cl}(\text{int}(A))$
(b) intuitionistic fuzzy semi closed set (IFSCS in short) if $\text{int}(\text{cl}(A)) \subseteq A$.

Definition 2.6. [6] Let (X, τ) be an IFTS and $A = \langle x, \mu_A, \nu_A \rangle$ be an IFS in X. Then the semi closure of A (scl (A) in short) and semi interior of A (sint (A) in short) are defined as
$\text{scl}(A) = \cap \{ K \mid K \text{ is an IFSCS in X and } A \subseteq K \}$
$\text{sint}(A) = \cup\{ G \mid G \text{ is an IFSOS in X and } G \subseteq A \}$.

Definition 2.7. [6] An IFS A= $\{\langle x, \mu_A(x), \nu_A(x)\rangle \mid x \in X\}$ in an IFTS (X, τ) is said to be an
(a) intuitionistic fuzzy α open set (IFαOS in short) if A ⊆int(cl(int(A)))
(b) intuitionistic fuzzy α closed set (IFαCS in short) if cl(int(cl(A))) ⊆ A.

Definition 2.8. [9] Let (X, τ) be an IFTS and A= $\langle x, \mu_A, \nu_A \rangle$ be an IFS in X. Then the α closure of A (αcl (A) in short) and α interior of A (αint (A) in short) are defined as
αcl (A) = ∩ { K | K is an IFαCS in X and A ⊆ K }
αint (A) = ∪ {G | G is an IFαOS in X and G ⊆ A }.

Result 2.2. [9] Let A be an IFS in (X, τ). Then,
(a) αcl (A) = A ∪ cl(int(cl(A)))
(b) αint (A) = A ∩ int(cl(int(A))).

Definition 2.9. [6] An IFS A= $\{\langle x, \mu_A(x), \nu_A(x)\rangle \mid x \in X\}$ in an IFTS (X, τ) is said to be an
(a) intuitionistic fuzzy regular open set (IFROS in short) if A = int(cl (A))
(b) intuitionistic fuzzy regular closed set (IFRCS in short) if cl(int (A)) = A.

Definition 2.10. [6] An IFS A= $\{\langle x, \mu_A(x), \nu_A(x)\rangle \mid x \in X\}$ in an IFTS (X, τ) is said to be an
(a) intuitionistic fuzzy pre-open set (IFPOS in short) if A ⊆int(cl (A))
(b) intuitionistic fuzzy pre-closed set (IFPCS in short) if cl(int (A)) ⊆ A.

Definition 2.11. [12] An IFS A= $\{\langle x, \mu_A(x), \nu_A(x)\rangle \mid x \in X\}$ in an IFTS (X, τ) is said to be an
(a) intuitionistic fuzzy generalized open set (IFGOS in short) if int (A)⊇ U whenever A ⊇ U and U is an IFCS
(b) intuitionistic fuzzy generalized closed set (IFGCS in short) if cl (A) ⊆ U whenever A ⊆ U and U is an IFOS.

Definition 2.12. [11] An IFS A= $\{\langle x, \mu_A(x), \nu_A(x)\rangle \mid x \in X\}$ in an IFTS (X, τ) is said to be an
(a) intuitionistic fuzzy generalized semi open set (IFGSOS in short) if sint (A)⊇ U whenever A ⊇ U and U is an IFCS
(b) intuitionistic fuzzy generalized semi closed set (IFGSCS in short) if scl (A) ⊆ U whenever A ⊆ U and U is an IFOS.

Definition 2.13. [9] An IFS A= $\{\langle x, \mu_A(x), \nu_A(x)\rangle \mid x \in X\}$ in an IFTS (X, τ) is said to be an
(a) intuitionistic fuzzy α generalized open set (IFαGOS in short) if αint (A)⊇ U whenever A ⊇ U and U is an IFCS
(b) intuitionistic fuzzy α generalized closed set (IFαGCS in short) if αcl (A) ⊆ U whenever A ⊆ U and U is an IFOS.

Definition 2.14. [7] An IFS A= $\{\langle x, \mu_A(x), \nu_A(x)\rangle \mid x \in X\}$ in an IFTS (X, τ) is said to be an

(a) intuitionistic fuzzy semi-pre open set (IFSPOS in short) if there exists an IFPOS B such that B ⊆ A⊆cl (B)

(b) intuitionistic fuzzy semi-pre closed set (IFSPCS in short) if there exists an IFPCS B such that int (B) ⊆ A ⊆ B.

Definition 2.15. [10] Let (X, τ) be an IFTS and A= $\langle x, \mu_A, \nu_A \rangle$ be an IFS in X. Then the intuitionistic fuzzy semipre closure of A (spcl (A) in short) and intuitionistic fuzzy semipre interior of A (spint(A)) are defined as

spcl (A) = ∩ { K | K is an IFSPCS in X and A ⊆ K }

spint (A) = ∪ { G | G is an IFSPOS in X and G ⊆ A }.

Definition 2.16. [1] An IFS A= $\{\langle x, \mu_A(x), \nu_A(x)\rangle \mid x \in X\}$ in an IFTS (X, τ) is said to be an

(a) intuitionistic fuzzy presemi open set (IFPSOS in short) if spint(A)⊇ U whenever A ⊇ U and U is an IFGCS

(b) intuitionistic fuzzy presemi closed set (IFPSCS in short) if spcl (A) ⊆ U whenever A ⊆ U and U is an IFGOS.

3. Intuitionistic fuzzy presemi weakly closed set

Definition 3.1. An IFS A in an IFTS (X, τ) is said to be an intuitionistic fuzzy presemi weakly closed set (IFPSWCS in short) if IFint(IFcl(IFint(A))) ⊆ U whenever A ⊆ U, U is IFGO in X. The family of all IFPSWCSs of an IFTS (X, τ) is denoted by IFPSWCS(X).

Example 3.1. Let X = {a, b} and let τ = $\{0_\sim, T_1, T_2, 1_\sim\}$ be an IFT on X, where $T_1 = \langle x, (0.6, 0.7), (0.4, 0.3)\rangle$, $T_2 = \langle x, (0.4, 0.2), (0.6, 0.5)\rangle$. Then the IFS
$A = \langle x, (0.6, 0.4), (0.4, 0.6)\rangle$ is an IFPSWCS in X

Theorem 3.1. Every IFCS is an IFPSWCS but not conversely.

Proof: Let A be an IFCS in(X, τ). Let U be an IFGOS in (X, τ) such that A ⊆ U. Since A is an intuitionistic fuzzy closed, IFcl(A)=A and hence IFcl(A)⊆U. But IFcl(IFint(A)) ⊆ IFcl(A). Therefore IFint(IFcl(IFint (A))) ⊆ U. Hence A is an IFPSWCS in X.

Example 3.2. Let X = {a, b} and let τ = $\{0_\sim, T_1, T_2, 1_\sim\}$ be an IFT on X, where $T_1 = \langle x, (0.3, 0.5), (0.7, 0.5)\rangle$, $T_2 = \langle x, (0.7, 0.6), (0.3, 0.4)\rangle$. Then the IFS
$A = \langle x, (0.6, 0.5), (0.4, 0.5)\rangle$ is an IFPSWCS in X but not an IFCS.

Theorem 3.2. Every IFαCS is an IFPSWCS but not conversely.

Proof: Let A be an IFαCS in(X, τ). Let U be an IFGOS in (X, τ) such that A ⊆ U. Since A is IFαCS, IFcl (IFint (IFcl (A))) ⊆ A. Therefore, IFcl(IFint (A)) ⊆IFcl(IFint(IFcl (A))) ⊆ A ⊆ U. Therefore, IFint(IFcl(IFint (A))) ⊆ U. Hence A is an IFPSWCS in X.

Example 3.3. Let X = {a, b} and let τ = $\{0_\sim, T_1, T_2, 1_\sim\}$ be an IFT on X, where $T_1 = \langle x, (0.5, 0.4), (0.2, 0.3)\rangle$, $T_2 = \langle x, (0.2, 0.4), (0.5, 0.4)\rangle$. Then the IFS

$A = \langle x, (0.3, 0.4), (0.4, 0.4)\rangle$ is an IFPSWCS in X but not an IFαCS.

Theorem 3.3 Every IFSCS is an IFPSWCS but not conversely.
Proof: Let A be an IFSCS in(X, τ). Let U be an IFGOS in (X, τ) such that A ⊆ U. Since A is IFSCS, IFint(IFcl(A))⊆A and A⊆U. Therefore IFint(IFcl(A))⊆ U. Therefore IFint(IFcl(IFint(A))) ⊆ U. Hence A is an IFPSWCS in X.

Example 3.4. Let X = {a, b } and let $\tau = \{ 0_\sim, T_1, T_2, T_3, 1_\sim\}$ be an IFT on X, where $T_1 = \langle x, (0.4, 0.5), (0.6, 0.5)\rangle$, $T_2 = \langle x, (0.2, 0.3), (0.8, 0.7)\rangle$ and $T_3 = \langle x, (0.8, 0.5), (0.2, 0.2)\rangle$. Then the IFS $A = \langle x, (0.3, 0.4), (0.5, 0.6)\rangle$ is an IFPSWCS in X but not an IFSCS.

Theorem 3.4. Every IFRCS is an IFPSWCS but not conversely.
Proof: Let A be an IFRCS in (X, τ). Let U be an IFGOS in (X, τ) such that A ⊆ U. Since A is IFRCS, IFcl(IFint(A))=A⊆U. Therefore, IFcl(IFint(A))⊆U. Therefore IFint(IFcl(IFint(A))) ⊆ U. Hence A is an IFPSWCS in X.

Example 3.5. Let X = {a, b} and let $\tau = \{0_\sim, T_1, T_2, 1_\sim\}$ be an IFT on X, where $T_1 = \langle x, (0.8, 0.6), (0.2, 0.4)\rangle$, $T_2 = \langle x, (0.5, 0.4), (0.5, 0.6)\rangle$. Then the IFS $A = \langle x, (0.7, 0.5), (0.3, 0.5)\rangle$ is an IFPSWCS in X but not an IFRCS.

Theorem 3.5. Every IFPCS is an IFPSWCS but not conversely.
Proof: Let A be an IFPCS in (X, τ). Let U be an IFGOS in (X, τ) such that A ⊆ U. Since A is IFPCS, IFcl(IFint((A))⊆A and A⊆U. Therefore IFcl(IFint(A))⊆U. Therefore IFint(IFcl(IFint(A)))⊆U. Hence A is an IFPSWCS in X.

Example 3.6. Let X={a,b} and let $\tau = \{0_\sim, T_1, T_2, 1_\sim\}$ be an IFT on X, where $T_1 = \langle x, (0.4, 0.2), (0.4, 0.8)\rangle$, $T_2 = \langle x, (0.6, 0.8), (0.3, 0.1)\rangle$. Then the IFS $A = \langle x, (0.4, 0.3), (0.4, 0.7)\rangle$ is an IFPSWCS in X but not an IFPCS.

Theorem 3.6. Every IFαGCS is an IFPSWCS but not conversely.
Proof: Let A be an IFαGCS in (X, τ). Let U be an IFGOS in (X, τ) such that A ⊆ U. By definition 2.13 and result 2.2, A ∪ IFcl(IFint(IFcl (A))) ⊆ U. Therefore IFcl(IFint(IFcl (A))) ⊆ U and IFcl(IFint (A)) ⊆IFcl(IFint(IFcl (A))) ⊆ U. Therefore IFint(IFcl(IFint (A))) ⊆ U. Hence A is an IFPSWCS in X.

Example 3.7. Let X= {a, b} and let $\tau = \{0_\sim, T_1, T_2, 1_\sim\}$ be an IFT on X, where $T_1 = \langle x, (0.5, 0.4), (0.3, 0.4)\rangle$, $T_2 = \langle x, (0.3, 0.3), (0.5, 0.6)\rangle$. Then the IFS $A = \langle x, (0.4, 0.4), (0.5, 0.4)\rangle$ is an IFPSWCS in X but not an IFαGCS.

Remark 3.1. The union of any two IFPSWCS's need not be an IFPSWCS in general as seen from the following example.

Example 3.8. Let X={a, b} and let $\tau = \{0_\sim, T_1, T_2, 1_\sim\}$ be an IFT on X, where $T_1 = \langle x, (0.5, 0.6), (0.4, 0.3)\rangle$, $T_2=\langle x, (0.7, 0.7), (0.3, 0.3)\rangle$. Then the IFSs $A =\langle x, (0.3, 0.7), (0.7, 0.3)\rangle$, $B=\langle x, (0.5, 0.3), (0.4, 0.7)\rangle$ are IFPSWCSs but A∪B is not an IFPSWCS in X.

Remark 3.2. From the above discussion we have the following implications are true:

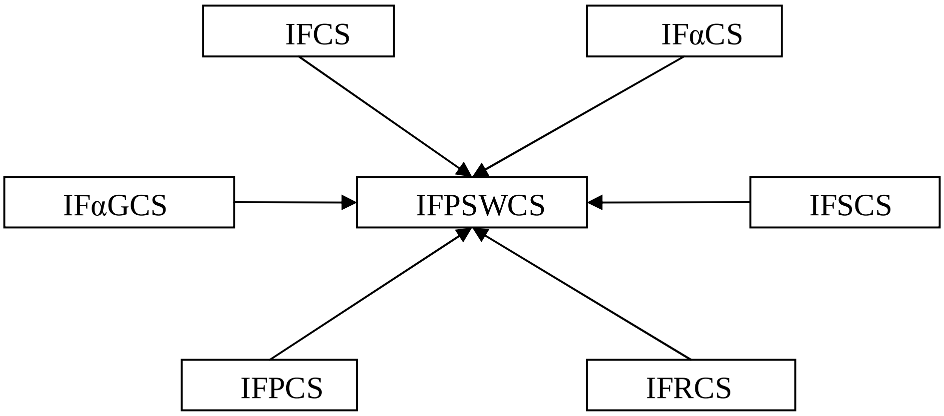

Figure 1: Relationship between intuitionistic fuzzy presemi weakly closed set and other existing intuitionistic fuzzy closed sets

In this figure, A → B denotes A implies B but not conversely.

3.1. Intuitionistic fuzzy presemi weakly open set

Definition 3.1.1. An IFS A in an IFTS (X, τ) is said to be an intuitionistic fuzzy presemi weakly open set (IFPSWOS in short) if IFcl(IFint(IFcl(A)))⊇ U whenever A ⊇ U, U is IFGC in X. The family of all IFPSWOSs of an IFTS (X, τ) is denoted by IFPSWOS(X).

Example 3.1.1. Let X={a, b} and let $\tau = \{0_\sim, T_1, T_2, 1_\sim\}$ be an IFT on X, where $T_1 = \langle x, (0.5, 0.3), (0.3, 0.2)\rangle$, $T_2 = \langle x, (0.1, 0.2), (0.7, 0.6)\rangle$. Then the IFS $A = \langle x, (0.6, 0.5), (0.2, 0.3)\rangle$ is an IFPSWOS in X.

Theorem 3.1.1. For any IFTS (X, τ), we have the following:
(1) Every IFOS is an IFPSWOS but not conversely.
(2) Every IFαOS is an IFPSWOS but not conversely.
(3) Every IFPOS is an IFPSWOS but not conversely.
(4) Every IFROS is an IFPSWOS but not conversely.

Proof: The proof is straight forward. The converse of the above statement need not be true in general as seen from the following examples.

Example 3.1.2. Let X={a, b} and let $\tau = \{0_\sim, T_1, T_2, 1_\sim\}$ be an IFT on X, where $T_1 = \langle x, (0.6, 0.4), (0.4, 0.3)\rangle$, $T_2 = \langle x, (0.2, 0.3), (0.8, 0.7)\rangle$. Then the IFS $A = \langle x, (0.7, 0.6), (0.3, 0.4)\rangle$ is an IFPSWOS in X but not an IFOS.

Example 3.1.3. Let X ={a, b} and let $\tau = \{0_\sim, T_1, T_2, 1_\sim\}$ be an IFT on X, where $T_1 = \langle x, (0.1, 0.2), (0.9, 0.8)\rangle$, $T_2 = \langle x, (0.5, 0.4), (0.3, 0.4)\rangle$. Then the IFS $A = \langle x, (0.4, 0.5), (0.3, 0.3)\rangle$ is an IFPSWOS in X but not an IFαOS.

Example 3.1.4. Let X={a, b} and let τ={$0_\sim$, T_1, T_2, $1_\sim$**}** be an IFT on X, where T_1 = $\langle x, (0.3, 0.3), (0.7, 0.6)\rangle$, T_2=$\langle x, (0.5, 0.6), (0.5, 0.4)\rangle$. Then the IFS A = $\langle x, (0.6, 0.5), (0.4, 0.4)\rangle$ is an IFPSWOS in X but not an IFPOS.

Example 3.1.5. Let X= {a, b} and let τ = {$0_\sim$, T_1, T_2, $1_\sim$**}** be an IFT on X, where T_1 = $\langle x, (0.5, 0.3), (0.4, 0.3)\rangle$, T_2=$\langle x, (0.3, 0.2), (0.7, 0.8)\rangle$. Then the IFS A = $\langle x, (0.5, 0.6), (0.5, 0.4)\rangle$ is an IFPSWOS in X but not an IFROS.

Theorem 3.1.2. An IFS A of an IFTS (X, τ) is an IFPSWOS if and only if F $\subseteq$IFcl(IFint(IFcl(A))) whenever F is an IFCS and F $\subseteq$ A.
Proof: Necessity: Suppose A is an IFPSWOS in X. Let F be an IFCS and F $\subseteq$ A. Then F^c is an IFOS in X such that $A^c \subseteq F^c$. Since A^c is an IFPSWCS, IFint(IFcl(IFint(A^c))) $\subseteq F^c$. Hence (IFcl(IFint(IFcl(A))))$^c \subseteq F^c$. This implies F $\subseteq$IFcl(IFint(IFcl(A))).
Sufficiency: Let A be an IFS of X and let F$\subseteq$IFcl(IFint(IFcl(A))) whenever F is an IFCS and F $\subseteq$ A. Then $A^c \subseteq F^c$ and F^c is an IFOS. By hypothesis, (IFcl(IFint(IFcl(A))))$^c \subseteq F^c$. Hence IFint(IFcl(IFint(A^c))) $\subseteq F^c$. Hence A is an IFPSWOS of X.

3.2. Applications of fuzzy presemi weakly closed set
Definition 3.2.1. An IFTS (X, τ**)** is called an intuitionistic fuzzy $_{PSW}T_{1/2}$ (IF $_{PSW}T_{1/2}$ in short) space if every IFPSWCS in X is an IFCS in X

Definition 3.2.2. An IFTS (X, τ**)** is called an intuitionistic fuzzy $_{PSW}T_k$ (IF $_{PSW}T_k$in short) space if every IFPSWCS in X is an IFPCS in X.

Theorem 3.2.1. Every IF $_{PSW}T_{1/2}$ space is an IF $_{PSW}T_k$ space but not conversely.
Proof: Let X be an IF $_{PSW}T_{1/2}$ space and let A be an IFPSWCS in X. By hypothesis, A is an IFCS in X. since every IFCS in an IFPCS in X. Hence X is an IF $_{PSW}T_k$ space.

Example 3.2.1. Let X = {a, b} and let τ = {$0_\sim$, T_1, T_2, $1_\sim$**}** be an IFT on X, where T_1 = $\langle x, (0.6, 0.5), (0.4, 0.4)\rangle$, T_2 =$\langle x, (0.7, 0.6), (0.3, 0.4)\rangle$. Then (X, τ**)** is an IF $_{PSW}T_k$ space. But not an IF $_{PSW}T_{1/2}$ space since IFS A = $\langle x, (0.5, 0.4), (0.4, 0.5)\rangle$ is an IFPSWCS in X but not an IFCS.

Theorem 3.2.2. Let (X, τ**)** be an IFTS and X is an IF $_{PSW}T_{1/2}$ space then
(1) Arbitrary union of IFPSWCS is an IFPSWCS.
(2) Finite intersection of IFPSWCS is an IFPSWCS.
Proof: (1) Let $\{A_i\}_{i\in J}$ is a collection of IFPSWCS in an IF $_{PSW}T_{1/2}$ space (X, τ**)**.Therefore, every IFPSWCS is an IFCS. But the union of IFCS is an IFCS. Hence the union of IFPSWCS is an IFPSWCS in X.
(2) It can be proved by taking complement in (1).

Theorem 3.2.3. An IFTS X is an IF $_{PSW}T_k$ space if and only if IFPSWOS(X) = IFPOS(X).
Proof: Necessity: Let A be an IFPSWOS in X, then A^c is an IFPSWCS in X. By hypothesis A^c is an IFPCS in X. Therefore, A is an IFPOS in X. Hence IFPSWOS(X) = IFPOS(X).

Sufficiency: Let A be an IFPSWCS in X. Then A^c is an IFPSWOS in X. By hypothesis A^c is an IFPOS in X. Therefore, A is an IFPCS in X. Hence X is an IF $_{PSW}T_k$ space.

Theorem 3.2.4. An IFTS X is an IF $_{PSW}T_{1/2}$ space if and only if IFPSWOS(X) = IFOS(X).

Proof: Necessity: Let A be an IFPSWOS in X, then A^c is an IFPSWCS in X. By hypothesis A^c is an IFCS in X. Therefore, A is an IFOS in X. Hence IFPSWOS(X) = IFOS(X).

Sufficiency: Let A be an IFPSWCS in X. Then A^c is an IFPSWOS in X. By hypothesis A^c is an IFOS in X. Therefore, A is an IFCS in X. Hence X is an IF $_{PSW}T_{1/2}$ space.

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