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SOFT INTERVAL VALUED INTUITIONISTIC FUZZY SEMI-PRE GENERALIZED CLOSED SETS

A.Arokia Lancy[1] , I.Arockiarani *& S.Jafari[2]

[1]Department of Mathematics,Nirmala College for women, Coimbatore, Tamilnadu, India.

[2]Professor of Mathematics,College of Vestsjaelland South Herrestraede 11 ,4200 Slagelse Denmark

Abstract: The purpose of this paper is to introduce some generalized closed sets of general topology to soft interval valued intuitionistic fuzzy topology. In particular the soft interval valued intuitionistic fuzzy semi-pre generalized closed sets along with its characterization are discussed.

Keywords: Soft interval valued intuitionistic fuzzy open set (semi-open set, pre-open set, semi-pre open set, α - open set) soft interval valued intuitionistic semi –pre generalized closed set.

1. INTRODUCTION:

The year 1999, gave a new start to a theory which was very convenient and easily applicable to the real life problems. This theory named Soft Set Theory was developed by D.Molodtsov [18]. He paved a way for attaining solution to complicated decision making problems that are complicated due to some uncertainty and incompleteness of information.In 2003, Maji et al [16] developed several basic notions for this theory.

In 2011, Muhammad Shabir and Munazza Naz [19] developed the soft topology. Following which there was a tremendous growth in soft topological concepts, many researchers [5,10,13,20] work on this area to touch new horizons.

Slowly the soft set theory was dragged into interval valued intuitionistic fuzzy set, Y. Jiang et.al [22] and Jinyan Wang et.al [12] studied interval valued intuitionistic fuzzy soft sets and studied their properties. In 2013, Anjan Mukherjee et. al [4] developed interval valued intuitionistic fuzzy soft topological spaces. With this intuition we have entered in to generalization of soft interval valued intuitionistic fuzzy sets.

This paper aims at generalizing the soft interval valued intuitionistic fuzzy semi-pre closed sets and layout some of its properties along with examples.

2. PRELIMINARIES

DEFINITION :2.1[17] A pair (F,E) is called a soft set (over U) if and only if F is a mapping of E into the set of all subsets of the set U.

DEFINITION :2.2[15] A soft set (F,A) over U is said to be a NULL soft set denoted by Φ , if $\forall$ e $\in$ A, F(e) = $\emptyset$.

DEFINITION:2.3[15] A soft set (F,A) over U is said to be an absolute soft set denoted by $\tilde{A}$, if $\forall$ e $\in$ A, F(e) = U. Clearly $\Phi^c = \tilde{A}$ and $\breve{A}^c = \Phi$.

DEFINITION:2.4 [15] The union of two soft sets (F,A) and (G,B) over the common universe U is the soft set (H,C) , where C = A ∪ B and $\forall$ e $\in$ C,

$$H(e) = \begin{cases} F(e) if\ e \in A - B \\ G(e) if\ e \in B - A \\ F(e) \cup G(e) if\ e \in A \cap B \end{cases}$$

And it is written as (F,A) $\cup (G, B) = (H, C)$.

DEFINITION:2.5[15] The intersection (H, C) of two soft sets (F,A) and (G,B) over the common universe U, denoted by (F,A) $\cap (G, B)$ is defined as C = A∩B and H(e) =F(e) ∩G(e) , $\forall$ e $\in$ C.

DEFINITION:2.6[18] Let τ be the collection of soft sets over X , then τ is said to be a soft topology on X if

i) Φ , $\tilde{X}$ belong to τ

ii) the union of any number of soft sets in τ belongs to τ.

iii) the intersection of any two soft sets in τ belongs to τ. The triplet (X, τ,E) is called soft topological space over X. The members of τ are said to be soft open sets in X.

DEFINITION:2.7 A soft set (F,E) of a soft topological space(X, τ,E) is called

(i) soft pre-open set**[5]** if (F,E) $\tilde{\subseteq}$ int(cl(F,E)).

(ii) soft α -open set**[5]** if (F,E) $\tilde{\subseteq}$ int(cl(int(F,E))).

(iii)soft β -open set**[20]** if (F,E) $\tilde{\subseteq}$ cl(int(cl(F,E))).

DEFINITION :2.8 [9] An intuitionistic fuzzy topology (IFT) on a non empty set X is a family τ of an intuitionistic fuzzy set (IFS) X satisfying the following axioms: (i) $0_\sim ,1_\sim \in \tau$ (ii) $G_1 \cap G_2 \in \tau$ (iii) $\cup G_i \in \tau$ for any arbitrary family $\{ G_i \ / \ i \in J\} \subseteq \tau$. In this case the pair (X, τ) is called an intuitionistic fuzzy topological space (IFTS) and any IFS in τ is known as an intuitionistic fuzzy open set (IFOS) in X.

DEFINITION: 2.9 [4]

Let (ξ_A, E) be an element of interval valued intuitionistic fuzzy set(IVIFS) (U;E), P(ξ_A, E) be the collection of all IVIFS subsets of (ξ_A, E). A sub family τ of P$(\xi_A, E)$is called an interval valued intuitionistic fuzzy soft topology on (ξ_A, E), if the following axioms are satisfied:

$[O_1]$ (ϕ_{ξ_A}, E) , (ξ_A, E) $\in \tau$

$[O_2]$ $\{(f_A^k, E)/k\epsilon K\} \subseteq \tau \Rightarrow \cup_{k\epsilon K}(f_A^k, E)\epsilon\tau$

$[O_3]$ $If\ (f_A, E), (g_A, E)\epsilon\tau, then\ (f_A, E)\cap(g_A, E)\epsilon\tau$

Then the pair $((\xi_A, E), \tau)$ is called an interval valued intuitionistic fuzzy soft topological space. The members of τ are called $\tau -$ open sets, where ϕ_{ξ_A}: A→IVIFS(U) is defined as $\phi_{\xi_A}(e)$= {<x,[0,0],[1,1>:xϵU}, ∀ e ∈ A]

DEFINITION: 2.10[4]

Let $((\xi_A, E), \tau)$ be an interval valued intuitionistic fuzzy soft topological space on (ξ_A, E) and (f_A, E) be an IVIFS in P(ξ_A, E). Then the union of all open IVIFS set of (f_A, E) is called the interior of (f_A, E) and is denoted by int (f_A, E) and defined by int (f_A, E) = $\cup$ $\{(g_A, E)/(f_A, E)$ is a neighborhood of $(g_A, E)\}$.

DEFINITION: 2.11[4]

Let $((\xi_A, E), \tau)$ be an interval valued intuitionistic fuzzy soft topological space on (ξ_A, E) and (f_A, E) be an IVIFS in P(ξ_A, E). Then the intersection of all closed IVIFS set containing (f_A, E) is called the closure of (f_A, E) and is denoted by cl(f_A, E) and defined by cl(f_A, E) = $\cap$ $\{(g_A, E)/(g_A, E)$is a IVIFS-closed set containing$(f_A, E)\}$.

DEFINITION: 2.12[21]

Let U be an initial universe and E be the set of parameters . Suppose that A,B ⊆ E, <F,A> and <G,B> are two interval-valued intuitionistic fuzzy soft sets, we say that <F,A> is an interval-valued intuitionistic fuzzy soft subset of <G,B> if and only if (i) A ⊆ B, (ii) ∀ e ∈ A, F(e) is an interval-valued intuitionistic fuzzy soft subset of G(e) , that is for all x∈ U, e ∈ A ,

$$\underline{\mu}_{F(e)}(x) \leq \underline{\mu}_{G(e)}(x)\ ,\ \overline{\mu}_{F(e)}(x) \leq \overline{\mu}_{G(e)}(x)$$

$$\underline{\gamma}_{F(e)}(x) \geq \underline{\gamma}_{G(e)}(x)\ ,\ \overline{\gamma}_{F(e)}(x) \geq \overline{\gamma}_{G(e)}(x)$$

DEFINITION: 2.13 [21]

An interval valued intuitionistic fuzzy soft set <F,A> over U is said to be a null interval valued intuitionistic fuzzy soft set denoted by Φ , if ∀ e ∈ A , $\mu_{F(e)}(x) = [0,0], \gamma_{F(e)}(x) = [1,1],$ x ∈ U.

DEFINITION: 2.14 [21]

An interval valued intuitionistic fuzzy soft set <F,A> over U is said to be an absolute interval valued intuitionistic fuzzy soft set denoted by $\sum$, if $\forall e \in A$, $\mu_{F(e)}(x)=[1,1], \gamma_{F(e)}(x)=[0,0]$, $x \in U$.

DEFINITION: 2.15 [13] A subset S of a topological space(X, τ) is called Q-set if cl(int(S)) = int(cl(S)).

3. SOFT VALUED INTUITIONISTIC FUZZY SEMI-PRE CLOSED SETS

In this section we have introduced soft interval valued intuitionistic fuzzy semi-pre closed sets and have listed their characterizations.

DEFINITION: 3.1

A soft interval valued intuitionistic fuzzy set is said to be

(i) semi-open if $f^A \cong$ cl(int(f^A))

(ii) pre-open if $f^A \cong$ int(cl(f^A))

(iii)semi pre-open if $f^A \cong$ cl(int(cl(f^A)))

(iv)α –open if $f^A \cong$ int(cl(int(f^A))), where A $\subseteq$ E (the parameter set).

The complements of the above sets are known as their respective closed sets.

DEFINITION: 3.2

A soft interval valued intuitionistic fuzzy set is termed soft interval valued intuitionistic fuzzy semi-pre generalized closed set (SIVIFSPGCS) if βcl (f^A) $\cong$ (U_E) whenever $f^A \cong U_E$ and U_E is a soft interval valued intuitionistic fuzzy semi open set (SIVIFSOS) in (X,τ, E), where E is the parameter set and A is a subset of E.

The complement of SIVIFSPGCS is called a soft interval valued intuitionistic fuzzy semi-pre generalized open set (SIVIFSPGOS).

EXAMPLE: 3.3

Let X= {a,b} , E = {e$_1$,e$_2$} and let $\tilde{X}$ = { (e$_1$,{$\frac{a}{([1,1],[0,0])},\frac{b}{([1,1],[0,0])}$}) , (e$_2$,{$\frac{a}{([1,1],[0,0])},\frac{b}{([1,1],[0,0])}$})},

Φ = { (e$_1$,{$\frac{a}{([0,0],[1,1])},\frac{b}{([0,0],[1,1])}$}) , (e$_2$,{$\frac{a}{([0,0],[1,1])},\frac{b}{([0,0],[1,1])}$})},

(f^1, E)= { (e$_1$,{$\frac{a}{([0.5,0.6],[0.2,0.3])},\frac{b}{([0.4,0.5],[0,0.1])}$}) , (e$_2$,{$\frac{a}{([0.4,0.5],[0.2,0.3])},\frac{b}{([0.4,0.5],[0,0])}$})}. Consider τ = {$\tilde{X}$, Φ , (f^1, E) } to be a soft interval valued intuitionistic fuzzy topology defined using the universal set X along with the parameter set E.

Let (f^2, E)={(e$_1$,{$\frac{a}{([0.4,0.5],[0.3,0.4])}$, $\frac{b}{([0.3,0.4],[0,0.2])}$}), (e$_2$,{$\frac{a}{([0.3,0.5],[0.4,0.5])}$, $\frac{b}{([0,0],[0.4,0.5])}$})}. Let U_E = (f^1, E) which is SIVIFSOS. βcl (f^2, E) ⊆̃ (f^1, E) , hence according to the definition (f^2, E) is SIVIFSPGCS.

THEOREM: 3.4 Every SIVIFCS in (X,τ , E) is SIVIFSPGCS but not conversely.

Proof: Let f^A ⊆̃ U_E and U_E be a SIVIFSOS in (X,τ,E) .

Then βcl (f^A) ⊆̃ cl (f^A) = f^A ⊆̃ U_E (by assumption), hence f^A is SIVIFSPGCS in (X,τ,E) .

EXAMPLE: 3.5

Example: 3.3 shows that (f^2, E) is SIVIFSPGCS but it is not SIVIFCS in (X,τ , E).

THEOREM: 3.6 Every SIVIFSPCS in (X,τ , E) is SIVIFSPGCS but not conversely.

Proof: Consider f^A to be SIVIFSPCS and let f^A ⊆̃ U_E, where U_E be a SIVIFSOS in (X,τ,E) .

By assumption, βcl (f^A) = f^A and f^A ⊆̃ U_E . Hence, we have βcl (f^A) ⊆̃ U_E , so f^A is SIVIFSPGCS in (X,τ,E) .

EXAMPLE: 3.7

Consider τ = {$\tilde{X}$, Φ , (f^1, E) , (f^2, E) , (f^3, E) , (f^4, E) }, where X = {a,b} and E = {e$_1$,e$_2$}, where

(f^1, E)= {(e$_1$, {$\frac{a}{([0.6,0.7],[0.2,0.3])}$, $\frac{b}{([0.7,0.8],[0.1,0.2])}$}), (e$_2$, {$\frac{a}{([0.5,0.6],[0.3,0.4])}$, $\frac{b}{([0.6,0.7],[0.2,0.3])}$})},

(f^2, E)= {(e$_1$, {$\frac{a}{([0.1,0.2],[0.7,0.8])}$, $\frac{b}{([0,0.1],[0.2,0.9])}$}), (e$_2$, {$\frac{a}{([0,0.1],[0.8,0.9])}$, $\frac{b}{([0,0.1],[0.2,0.9])}$})}.

(f^3, E)= {(e$_1$, {$\frac{a}{([0.6,0.7],[0.2,0.3])}$, $\frac{b}{([0.7,0.8],[0.1,0.2])}$}), (e$_2$, {$\frac{a}{([0.5,0.6],[0.3,0.4])}$, $\frac{b}{([0.6,0.7],[0.2,0.3])}$})}.

(f^4, E)= {(e$_1$, {$\frac{a}{([0.1,0.2],[0.7,0.8])}$, $\frac{b}{([0,0.1],[0.2,0.9])}$}), (e$_2$, {$\frac{a}{([0,0.1],[0.8,0.9])}$, $\frac{b}{([0,0.1],[0.2,0.9])}$})}.

Let (f^5, E) = {(e$_1$, {$\frac{a}{([0.7,0.8],[0.1,0.1])}$, $\frac{b}{([0.8,0.9],[0.1,0.1])}$}), (e$_2$, {$\frac{a}{([0.6,0.7],[0.2,0.3])}$, $\frac{b}{([0.7,0.8],[0.1,0.2])}$})} be a SIVIFS which is SIVIFSPGCS but not SIVIFSPCS.

THEOREM: 3.8 All the SIVIFSCS in (X,τ , E) is SIVIFSPGCS but not conversely.

Proof: Assume f^A to be SIVIFSCS and let f^A ⊆̃ U_E, where U_E be a SIVIFSOS in (X,τ,E) .

Since βcl (f^A) ⊆̃ scl (f^A) = f^A ⊆̃ U_E , we have βcl (f^A) ⊆̃ U_E , therefore f^A is SIVIFSPGCS.

EXAMPLE: 3.9

Example: 3.3 shows that (f^2, E) is SIVIFSPGCS but it is not SIVIFSCS in (X,τ , E).

THEOREM: 3.10 Each SIVIFPCS in (X,τ , E) is SIVIFSPGCS but not conversely.

Proof: Let f^A be SIVIFPCS, also assume that $f^A \tilde{\subseteq} U_E$, where U_E be a SIVIFSOS in (X,τ , E). By hypothesis, βcl (f^A) $\tilde{\subseteq}$ pcl (f^A) = f^A which implies that βcl (f^A) $\tilde{\subseteq}$ (f^A) $\tilde{\subseteq}$ U_E. hence f^A is SIVIFSPGCS.

REMARK : 3.11 Since every SIVIFαCS is a SIVIFPCS and since SIVIFPCS is SIVIFSPGCS we have every SIVIFαCS to be SIVIFSPGCS in (X,τ , E).

EXAMPLE: 3.12 Consider $\tau = \{\tilde{X}$, Φ , (f^1, E) , (f^2, E) , (f^3, E) , (f^4, E) }, where X = {a,b} and E = {e_1,e_2}, where the elements of τ are similar to Example 3.7, now let

(f^6, E) = {(e_1, $\{\frac{a}{([0.2,0.4],[0.2,0.5])}, \frac{b}{([0.3,0.5],[0.5,0.4])}\}$), ($e_2$, $\{\frac{a}{([0.1,0.4],[0.35,0.4])}, \frac{b}{([0.35,0.4],[0.4,0.6])}\}$)} be a SIVIFS which is SIVIFSPGCS but not SIVIFPCS.

THEOREM: 3.13 Every SIVIFRCS in (X,τ , E) is SIVIFSPGCS but not conversely.

Proof : Assume that f^A is SIVIFRCS in (X,τ , E) , since every SIVIFRCS is a SIVIFCS , by Theorem 3.4 , f^A is SIVIFSPGCS in (X,τ , E).

EXAMPLE: 3.14

Example: 3.12 , can be considered where (f^6, E) is SIVIFSPGCS but not SIVIFRCS.

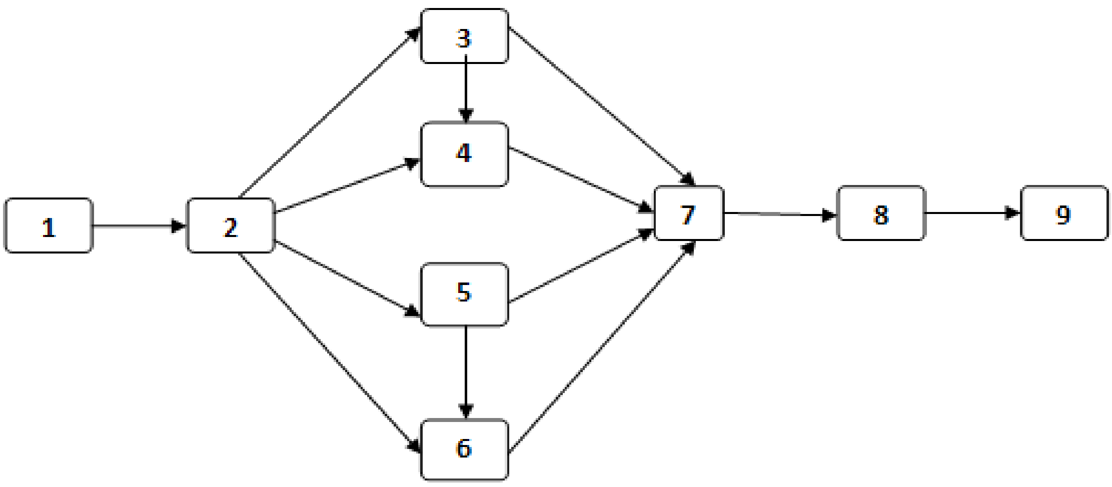
THEOREM: 3.15 Each SIVIFSPGCS in (X,τ , E) is SIVIFGSPCS but not conversely.

Proof: Let f^A be a SIVIFSPGCS in (X,τ , E) and let $f^A \tilde{\subseteq} U_E$, where U_E be a SIVIFOS in (X,τ , E). Since every SIVIFOS is SIVIFSOS in (X,τ , E) and by assumption βcl (f^A) $\tilde{\subseteq}$ U_E. Hence f^A is SIVIFSPGCS.

EXAMPLE: 3.16

The following diagram shows the relation between all the above sets with SIVIFSPGCS.

The reverse implications are not true in general.



1. SIVIFRCS 2. SIVIFCS 3. SIVIFSCS 4. SIVIFSPCS 5. SIVIFPCS

6. SIVIFαCS 7. SIVIFGCS 8. SIVIFSPGCS 9.SIVIFGSPCS

REMARK: 3.17 The union and intersection of any two SIVIFSPGCS in (X,τ , E) is not a SIVIFSPGCS which is evident from the following examples.

EXAMPLE: 3.18 Consider τ from Example 3.7 , let two new sets f^7 and f^8 be defined such that

(f^7, E)= {(e$_1$, $\{\frac{a}{([0.7,0.8],[0.1,0.1])}, \frac{b}{([0.8,0.9],[0.1,0.1])}\}$), (e$_2$, $\{\frac{a}{([0.6,0.7],[0.2,0.3])}, \frac{b}{([0.7,0.8],[0.1,0.2])}\}$)},

(f^8, E)= {(e$_1$, $\{\frac{a}{([0.4,0.5],[0.3,0.4])}, \frac{b}{([0.3,0.4],[0,0.1])}\}$), (e$_2$, $\{\frac{a}{([0.3,0.5],[0.3,0.4])}, \frac{b}{([0.4,0.4],[0,0.1])}\}$)}.

f^7 and f^8 are SIVIFSPGCS , whereas $f^7 \tilde{\cup} f^8$ is not SIVIFSPGCS.

DEFINITION: 3.19 Let f^E be a SIVIFS in a SIVIFTS (X,τ , E) . Then the semi-pre generalized interior of f^E and semi-pre generalized closure of f^E are defined by

1. $spgint(f^E) = \tilde{\cup} \{g^E / g^E is\ a\ SIVIFSPGOS\ in\ X\ and\ g^E \tilde{\subseteq} f^E\}$
2. $spgcl(f^E) = \tilde{\cap} \{k^E / k^E is\ a\ SIVIFSPGCS\ in\ X\ and\ f^E \tilde{\subseteq} k^E\}$

THEOREM: 3.20 If f^A is a SIVIFSOS and SIVIFSPGCS in (X,τ , E) then f^A is SIVIFSPCS. Proof: By assumption, f^A is a SIVIFSOS in (X,τ , E) and always $f^A \tilde{\subseteq} f^A$, hence βcl $(f^A) \tilde{\subseteq} f^A$ and also it is true that $f^A \tilde{\subseteq}$ βcl (f^A) . Hence f^A is SIVIFSPCS.

THEOREM: 3.21 Let (X,τ , E) be a SIVIFTS. If $f^A \tilde{\epsilon}$ SIVIFSPGCS(X) and for every $f^B \tilde{\epsilon}$ SIVIFS (X) also if $f^A \tilde{\subseteq} f^B \tilde{\subseteq}$ βcl (f^A) then $f^B \tilde{\epsilon}$ SIVIFSPGC (X).

Proof: Assume that $f^B \tilde{\subseteq} U_E$, where U_E be a SIVIFOS in (X,τ , E). By hypothesis $f^A \tilde{\subseteq} f^B$ which implies $f^A \tilde{\subseteq} U_E \Longrightarrow$ βcl $(f^A) \tilde{\subseteq} U_E$, since f^A is SIVIFSPGCS. Now $f^B \tilde{\subseteq}$ βcl (f^A)

$\Longrightarrow$ βcl $(f^B) \tilde{\subseteq}$ βcl (βcl $(f^A)) \tilde{\subseteq}$ βcl $(f^A) \tilde{\subseteq} U_E \Longrightarrow$ βcl $(f^B) \tilde{\subseteq} U_E \Longrightarrow U_E$ is SIVIFSPGCS(X).

THEOREM: 3.22 If f^A is a SIVIFS in (X,τ , E) , then the following statements imply each other.

(i) f^A is a SIVIFOS and SIVIFSPGCS in (X,τ , E)

(ii) f^A is a SIVIFROS in (X,τ , E)

Proof : (i) $\Longrightarrow$ (ii) Let f^A be SIVIFOS and SIVIFSPGCS in (X,τ , E) .

Since every SIVIFOS is SIVIFSOS, we have βcl $(f^A) \tilde{\subseteq} f^A$ by assumption, $\Longrightarrow$ int(cl(int(f^A))) $\tilde{\subseteq} f^A$. As f^A is SIVIFOS, f^A = int (f^A), ∴ int(cl(f^A)) $\tilde{\subseteq} f^A$. Also since, f^A is SIVIFOS it is SIVIFPOS in (X,τ , E) , hence $f^A \tilde{\subseteq}$ int(cl(f^A)) . ∴ f^A = int(cl(f^A)), hence f^A is SIVIFROS in (X,τ , E).

(ii) ⟹ (i) Let f^A be SIVIFROS in (X,τ , E), hence f^A = int(cl(f^A)) . Since every SIVIFROS is SIVIFOS, f^A is SIVIFOS and always $f^A \supseteq f^A$ ⟹ int(cl(f^A)) $\supseteq f^A$which implies f^A is SIVIFSCS. Hence by theorem 3.8, f^A is SIVIFSPGCS in (X,τ , E) .

THEOREM: 3.23 For a SIVIFOS f^A in (X,τ , E) , the following conditions are equivalent :

(i) f^A is a SIVIFCS in (X,τ , E)

(ii) f^A is a SIVIFSPGCS and a SIVIFQ set in (X,τ , E)

Proof : (i) ⟹ (ii) Since f^A is a SIVIFCS , it is SIVIFSPGCS in (X,τ , E). By hypothesis we have int(cl(f^A)) = int f^A = f^A = cl(f^A) = cl(int(f^A)) . Hence f^A is SIVIFQ set.

(ii) ⟹ (i) As f^A is SIVIFOS and SIVIFSPGCS in (X,τ , E) , then by Theorem: 3.22, f^A is a SIVIFROS in (X,τ , E). Therefore f^A = int(cl(f^A)) = cl(int(f^A)) = cl(f^A) , by hypothesis. Hence f^A is SIVIFCS in (X,τ , E)

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