Convergence of Intuionistic Fuzzy Filters in Syntopogenous Intuionisticfuzzy Strctures

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Abstract: In this paper we introduce theintutionistic fuzzy filter, convergence of intutionistic fuzzy filter in syntopogenousintutionistic fuzzy spaces and their properties are also studied.
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Introduction

The concept of a fuzzy set was introduced by Zadeh [18], and many topics in mathematics was introduced using the fuzzy sets. In 1983Atanassov [1, 2, 3, 4] generalized the fuzzy sets to intutionistic fuzzy sets, and later there has been much progress in the study of intutionistic fuzzy sets by many authors [5, 6]. Kandi let al.,[10] redefined the concept of intutionistic fuzzy set which was defined by Atanassov, in more simple form.

In 1963 Csâszar [7] introduced the syntopogenous structures which are a unified theory of topologies, proximities and uniformities. In 1983 Katssars and Petalas [8, 9] used the ideas of Csâszar and the concept of fuzzy set to introduce the fuzzy syntopogenous structures.Kandil et al.,11] used the ideas of Csâszarand,Katssars and Petalas [7, 8, 9] and the concept of intuitionistic fuzzy set redefined [10] to introduce the intuitionistic fuzzy syntopogenous structures.Recently Tantawy et al,. [17] introduced the convergence of fuzzy filter in fuzzy syntopogenous spaces.Also in [16] they defined some separation axioms on syntopogenous intuitionistic fuzzy structures.

Mondal and Samanta [12] introduced the definition of generalized intutionistic fuzzy sets.

Park and Park [13] used the generalized intutionistic fuzzy sets given by Mondal and Samanta to introduce the concept of generalized intutionistic fuzzy filter.

By using theintutionistic fuzzy set modified by **Kandil** and the notion of generalized intutionistic fuzzy filter given by Park and Park we will define theintutionistic fuzzy filter. Also we will introduce the convergence of intuitionistic fuzzy filter in syntopogenousintuitionistic fuzzy spaces using [16,17] and study their properties.

Preliminaries

In this section we recall many of the concepts and properties which are needed in the sequel and studied by others.

Definition 2.1:[9]An intuitionistic fuzzy set $\underline{A}$ (IFS for short) is an ordered pair $<A^1, A^2> \in I^X \times I^X$ whereI^X is the family of all fuzzy sets on a given non-empty set X such that $A^1 \subseteq A^2$ and denoted by $\underline{A} = <A^1, A^2>$.

The family of IFSs on X, will be denoted by II^X.

The IFS $\underline{1} = <1,1>$ is called the universal IFS, and the IFS $\underline{0} = <0,0>$ is called the empty IFS.

The binary operations on II^X are given in the following:

Definition 2.2:[9] Let $\underline{A} = <A^1, A^2>$ and $\underline{B} = <B^1, B^2>$ be two IFSs on a non-empty set X. then :

(1) $\underline{A} \subseteq \underline{B}$ iff $A^1 \subseteq B^1$ and $A^2 \subseteq B^2$.

(2) $\underline{A} = \underline{B}$ iff $A^1 = B^1$ and $A^2 = B^2$.

(3) $\underline{A} \cup \underline{B} = <A^1 \cup B^1, A^2 \cup B^2>$.

(4) $\underline{A} \cap \underline{B} = <A^1 \cap B^1, A^2 \cap B^2>$.

(5) $\underline{A}^c = <A^{2c}, A^{1c}>$.

According to above definitions we can generalized the operations of intersection and union to arbitrary family $\{\underline{A}_i : i \in J\}$ of IFSs as follows: $\bigcup_{i\in J} \underline{A}_i = <\bigcup_{i\in J} A_i^1, \bigcup_{i\in J} A_i^2>$ and $\bigcap_{i\in J} \underline{A}_i = <\bigcap_{i\in J} A_i^1, \bigcap_{i\in J} A_i^2>$.

Theorem 2.3:[9](II^X, $\cap$, $\cup$, ^{c}) is a Morgan Algebra i.e. it satisfies the following axioms :

(1)Commutative laws

i) $\underline{A} \cup \underline{B} = \underline{B} \cup \underline{A}$ ii) $\underline{A} \cap \underline{B} = \underline{B} \cap \underline{A}$

(2) Associative Laws

i) $(\underline{A} \cup \underline{B}) \cup \underline{C} = \underline{A} \cup (\underline{B} \cup \underline{C})$

ii) $(\underline{A} \cap \underline{B}) \cap \underline{C} = \underline{A} \cap (\underline{B} \cap \underline{C})$

(3) Identity laws

i) $\underline{A} \cup \underline{0} = \underline{A}$ ii) $\underline{A} \cup \underline{1} = \underline{1}$

iii) $\underline{A} \cap \underline{0} = \underline{0}$ iv) $\underline{A} \cap \underline{1} = \underline{A}$

(4) Distributive laws

i) $\underline{A} \cup (\underline{B} \cap \underline{C}) = (\underline{A} \cup \underline{B}) \cap (\underline{A} \cup \underline{C})$

ii) $\underline{A} \cap (\underline{B} \cup \underline{C}) = (\underline{A} \cap \underline{B}) \cup (\underline{A} \cap \underline{C})$

(5) De Morgan's laws

i) $(\underline{A} \cup \underline{B})^c = \underline{A}^c \cap \underline{B}^c$

ii) $(\underline{A} \cap \underline{B})^c = \underline{A}^c \cup \underline{B}^c$.

Definition 2.4:[9] Let X and Y be two non-empty sets, f : X$\to$Y be a function;

(1) If $\underline{A} = <A^1, A^2>$ is an IFS in X, then the image of $\underline{A}$ under f, denoted by

(2) $f(\underline{A})$ is an IFS in Y, defined by $f(\underline{A}) = <f(A^1), f(A^2)>$; where

$$f(A^i)(y) = \begin{cases} \sup_{x \in f^{-1}(x)} A_i(x) & if \quad f^{-1}(y) \neq \varphi \\ 0 & otherwise \end{cases} \quad \forall y \in Y,$$

and i=1, 2.

(3) If $\underline{B} = <B^1, B^2>$ is an IFS in Y, then the preimage of $\underline{B}$ under f, denoted by $f^{-1}(\underline{B})$ is the IFS in X defined by $f^{-1}(\underline{B}) = <f^{-1}(B^1), f^{-1}(B^2)>$, where $f^{-1}(B^1)(x) = B^1(f(x))$ and $f^{-1}(B^2) = B^2(f(x))$ $\forall$ x$\in$X.

The properties of the image and the primage of intuitionistic fuzzy set is the same as the fuzzy case as follows:

Theorem 2.5:[9] Let f : X$\to$Y be a function, $\underline{A}$, $\underline{B} \in II^X$ and $\{\underline{A}_i : i \in J\} \subseteq II^X$. Let $\underline{C}$, $\underline{D} \in II^Y$ and $\{\underline{C}_i : i \in J\} \subseteq II^Y$. Then:

(1) $\underline{A} \subseteq \underline{B} \Rightarrow f(\underline{A}) \subseteq f(\underline{B})$.

(2) $\underline{C} \subseteq \underline{D} \Rightarrow f^{-1}(\underline{C}) \subseteq f^{-1}(\underline{D})$.

(3) $\underline{A} \subseteq f^{-1}(f(\underline{A}))$, and the equality holds if f is injective.

(4) $f(f^{-1}(\underline{C})) \subseteq \underline{C}$, and the equality holds if f is surjective.

(5) $(f^{-1}(\underline{C}))^c = f^{-1}(\underline{C}^c)$.

(6) $f(\bigcup_{i \in J} \underline{A}_i) = \bigcup_{i \in J} f(\underline{A}_i)$.

(7) $f^{-1}(\bigcup_{i \in J} \underline{C}_i) = \bigcup_{i \in J} f^{-1}(\underline{C}_i)$.

(8) $f(\bigcap_{i \in J} \underline{A}_i) \subseteq \bigcap_{h \in J} f(\underline{A}_i)$, and the equality holds if f is injective,

(9) $\bigcap_{i \in J} f^{-1}(\underline{C}_i) = \bigcap_{i \in J} f^{-1}(\underline{C}_i)$.

(10) $f(\underline{0}) = \underline{0}$, if f is surjective, then $f(\underline{1}) = \underline{1}$.

(11) $f^{-1}(\underline{1}) = \underline{1}$ and $f^{-1}(\underline{0}) = \underline{0}$.

Now we introduce the concept of intuitionistic fuzzy point as follows.

Definition 2.6:[9] Let X be a nonempty set and x$\in$X be a fixed element, $\alpha, \beta \in$ I = [0,1] such that $\alpha \leq \beta$, β>0. An intuitionistic fuzzy set $x^{(\alpha,\beta)} = (x^{(\alpha)}, x^{(\beta)}) \in II^X$ is called an intuitionistic fuzzy point (IFp, for short) i.e. the IFp $x^{(\alpha,\beta)}$ is an ordered pair of two fuzzy points $x^{(\alpha)}$, $x^{(\beta)}$ where $x^{(\alpha)} \leq x^{(\beta)}$.

When α = 0. Then $x^{(\alpha)}$ = 0 and the intuitionistic fuzzy point $x^{(\alpha,\beta)}$ is called a vanishing intuitionistic fuzzy point (VIPs, for short), i.e. $x^{(0,\beta)} = (0, x^{(\beta)})$ where $\beta \in I^0 = (0, 1]$.

Theorem 2.7:[9] Let $\underline{A}$, $\underline{B} \in \text{II}^X$ and $\{\underline{A}_i : i \in J\} \subseteq \text{II}^X$, where $\underline{A}_i = \langle A_i^1, A_i^2 \rangle$. Then:

(1) $\underline{A} \subseteq \underline{B}$ iff $x^{(\alpha,\beta)} \in \underline{A}$ implies $x^{(\alpha,\beta)} \in \underline{B}$ $\forall$ $x^{(\alpha,\beta)}$ in X.

(2) $x^{(\alpha,\beta)} \in \bigcap_{i\in J}\underline{A}_i$ iff $x^{(\alpha,\beta)} \in \underline{A}_i$ $\forall$ $i \in J$.

(3) If there exist $i \in J$ such that $x^{(\alpha,\beta)} \in \underline{A}_i$, then $x^{(\alpha,\beta)} \in \bigcup_{i\in J}\underline{A}_i$.

(4) $\underline{A} = \bigcup \{x^{(\alpha,\beta)} : x^{(\alpha,\beta)} \in \underline{A}\}$.

Remark 2.8:[9]

The union of an IFS and its complement needs not be the universal IFS.

The intersection of an IFS and its complement needs not to be the empty IFS.

The statement; ($x^{(\alpha,\beta)} \notin \underline{A} \Leftrightarrow x^{(\alpha,\beta)} \in \underline{A}^c$) may not be true in general.

(i) In fuzzy setting, we observe that if $\{A_i : i \in J\}$ be a family of fuzzy sets, then for any fuzzy point $x^{(\alpha)}$, $x^{(\alpha)} \in \bigcup_{i\in J} A_1$ iff $x^{(\alpha)} \in A^1$ for some $i \in J$ and J is finite. But this is not true in the intuitionistic setting.

This is shown in the following examples:

Example 2.9:[9] Let X = {a, b, c} and $\underline{A} = \langle (a^{0.4}, b^{0.3}, c^{0.5}), (a^{0.5}, b^{0.3}, c^{0.7}) \rangle$. Then:

(i) $\underline{A}^c = \langle (a^{0.5}, b^{0.7}, c^{0.3}), (a^{0.6}, b^{0.7}, c^{0.5}) \rangle$.

(ii) $\underline{A} \cup \underline{A}^c = \langle (a^{0.5}, b^{0.7}, c^{0.5}), (a^{0.6}, b^{0.7}, c^{0.7}) \rangle \neq \underline{1}$.

(iii) $\underline{A} \cap \underline{A}^c = \langle (a^{0.4}, b^{0.3}, c^{0.3}), (a^{0.5}, b^{0.3}, c^{0.5}) \rangle \neq \underline{0}$.

(iv) If x = a, then $a^{(0.4,0.7)} \notin \underline{A}$ and $a^{(0.4,0.7)} \notin \underline{A}^c$.

Example 2.10:[9] Let X = {a, b} and consider the following IFSs;

$\underline{A} = \langle (a^{0.3}, b^{0.4}), (a^{0.5}, b^{0.7}) \rangle$ and $\underline{B} = \langle (a^{0.4}, b^{0.2}), (a^{0.4}, b^{0.3}) \rangle$. Then we have:

$\underline{A} \cup \underline{B} = \langle (a^{0.4}, b^{0.4}), (a^{0.5}, b^{0.7}) \rangle$, $x^{(0.4,0.7)} \in \underline{A} \cup \underline{B}$ while $x^{(0.4,0.7)} \notin \underline{A}$ and $x^{(0.4,0.7)} \notin \underline{B}$.

Definition 2.11:[9] Let $\underline{A} = \langle A^1, A^2 \rangle$ and $\underline{B} = \langle B^1, B^2 \rangle$ be two IFSs on a non-empty set X and $x^{(\alpha,\beta)}$ be an IFp in X. Then:

(i) $\underline{A}$ and $\underline{B}$ are said to be quasi-coincident, and denoted by $\underline{A}\, q\, \underline{B}$ if $A^1\, q\, B^2$ or $A^2\, q\, B^1$.

If $\underline{A}$ is not quasi-coincident with $\underline{B}$, then wewrite $\underline{A} \not q \underline{B}$ i.e. $\underline{A} \not q \underline{B}$ if $A^1 \not q B^2$ and $A^2 \not q B^1$.

(ii) $x^{(\alpha,\beta)}\, q\, \underline{A}$ if $\alpha > A_2^c(x)$ or $\beta > A_1^c(x)$ i.e. $x^{(\alpha,\beta)}\, q\, \underline{A}$ if $x^{(\alpha)}\, q\, A^2$ or $x^{(\beta)}\, q\, A^1$.

The properties of the quasi- coincident relation were given in the following theorem:

Theorem 2.12:[9] Let $f : X \rightarrow Y$ be a function, $\underline{A}$, $\underline{B}$, $\underline{C} \in \text{II}^X$, $\underline{D}$, $\underline{E} \in \text{II}^Y$ and $\{\underline{A}_i : i \in J\} \subseteq \text{II}^X$ and $x^{(\alpha,\beta)}, y^{(\gamma,\delta)} \in X^{IP}$. Then:

(1) $\underline{A} \not q \underline{B} \Leftrightarrow \underline{A} \subseteq \underline{B}^c$.

(2) $\underline{A} \cap \underline{B} = \underline{0} \Rightarrow \underline{A} \not q \underline{B}$.

(3) $x^{(\alpha,\beta)} \not q \underline{A} \Leftrightarrow x^{(\alpha,\beta)} \in \underline{A}^c$.

(4) $\underline{A} \not q \underline{A}^c$.

(5) $\underline{A} \not q \underline{B}$, $\underline{C} \subseteq \underline{B} \Rightarrow \underline{A} \not q \underline{C}$.

(6) $\underline{A} \subseteq \underline{B} \Leftrightarrow (x^{(\alpha,\beta)}\, q\, \underline{A} \Rightarrow x^{(\alpha,\beta)}\, q\, \underline{B}$ $\forall$ $x^{(\alpha,\beta)}$ in X).

(7) $\underline{A}\, q\, \underline{B} \Leftrightarrow x^{(\alpha,\beta)}\, q\, \underline{B}$, for some $x^{(\alpha,\beta)} \in \underline{A}$.

(8) $x^{(\alpha,\beta)}\, q\, (\bigcup_{i\in J}\underline{A}_i) \Leftrightarrow \exists$ $i \in J$ such that $x^{(\alpha,\beta)}\, q\, \underline{A}_i$,

(9) If $x^{(\alpha,\beta)}\, q\, \bigcap_{i\in J}\underline{A}_i$, then $x^{(\alpha,\beta)}\, q\, \underline{A}_i$ for all $i \in J$.

(10) x$\neq$ y $\Rightarrow$ $x^{(\alpha,\beta)}$ $\not q$ $y^{(\gamma,\delta)}$ for all $\alpha,\beta,\gamma,\delta \in$ I.

(11) $x^{(\alpha,\beta)}$ $\not q$ $y^{(\gamma,\delta)}$ $\Leftrightarrow$ x$\neq$ y or x = y and ($\alpha+\delta\leq 1$ and $\beta+\gamma\leq 1$).

(12) $\underline{A}\ q\ \underline{B} \Rightarrow f(\underline{A})\ q\ f(\underline{B})$ if f is bijection.

(13) $\underline{D}\ \not q\ \underline{E} \Rightarrow f^{-1}(\underline{D})\ \not q\ f^{-1}(\underline{E})$.

Definition 2.13:[10] Asemi-topogenous intuitionistic fuzzy order on X is a binary relation $\prec\prec$ on II^X satisfying the following axioms :

(IFO1) $\underline{0} \prec\prec \underline{0}$ and $\underline{1} \prec\prec \underline{1}$;

(IFO2) $\underline{A} \prec\prec \underline{B}$ implies $\underline{A} \subseteq \underline{B}$;

(IFO3) $\underline{A} \subseteq \underline{A}' \prec\prec \underline{B}' \subseteq \underline{B}$ implies $\underline{A} \prec\prec \underline{B}$.

Definition 2.14:[10]Asemi-topogenousintuitionistic fuzzy order $\prec\prec$ on a set X is called :

(i) topogenousintuitionistic fuzzy order on X if it is satisfies the condition ;

$$\underline{A}_i \prec\prec \underline{B}_i \ (\, i = 1,2,3,\ldots,n\,) \text{ imply } \bigcup_{i=1}^{n}\underline{A}_i \prec\prec \bigcup_{i=1}^{n}\underline{B}_i \text{ and } \bigcap_{i=1}^{n}\underline{A}_i \prec\prec \bigcap_{i=1}^{n}\underline{B}_i .$$

(ii)perfect semi-topogenous intuitionistic fuzzy order on X if it is satisfies the condition :

$$\underline{A}_i \prec\prec \underline{B}_i \ (\, i\in J\,) \text{ implies } \bigcup_{i\in J}\underline{A}_i \prec\prec \bigcup_{i\in J}\underline{B}_i .$$

(iii) biperfecttopogenousintuitionistic fuzzy order on X if it is satisfies the condition :

$$\underline{A}_i \prec\prec \underline{B}_i \ (\, i\in J\,) \text{ implies } \bigcup_{i\in J}\underline{A}_i \prec\prec \bigcup_{i\in J}\underline{B}_i \text{ and } \bigcap_{i\in J}\underline{A}_i \prec\prec \bigcap_{i\in J}\underline{B}_i .$$

Where J is any index set.

Definition 2.15 :[10] Let $\prec\prec_1$ and $\prec\prec_2$ be two semi-topogenous(resp.topogenous, perfect semi-topogenous,biperfecttopogenous)intuitionistic fuzzy orders,then we say that $\prec\prec_2$ is finer than $\prec\prec_1$ (or $\prec\prec_1$ is coarser than $\prec\prec_2$),denoted by $\prec\prec_1 \subseteq \prec\prec_2$ if $\underline{A} \prec\prec_1 \underline{B}$ implies $\underline{A} \prec\prec_2 \underline{B}$.

Definition 2.16:[10] The complement of asemi-topogenous(resp.topogenous, perfect semi-topogenous,biperfecttopogenous) intuitionistic fuzzy order $\prec\prec$ on X,denoted by $\prec\prec^c$ is defined by ; $\underline{A} \prec\prec^c \underline{B}$ iff $\underline{B}^c \prec\prec \underline{A}^c$.Also is called symmetrical if $\underline{A} \prec\prec \underline{B}$ implies $\underline{A} \prec\prec^c \underline{B}$.

Definition 2.17:[10] A syntopogenousintuitionistic fuzzy structure on a set X is a non-empty family $\underline{S}$ of topogenous intuitionistic fuzzy orders on X having the following two properties :

(IFS1) If $\prec\prec'$, $\prec\prec'' \in \underline{S}$,then there exist an $\prec\prec \in \underline{S}$ finer than $\prec\prec'$ and $\prec\prec''$.

(IFS2) If $\prec\prec \in \underline{S}$,then there exists an $\prec\prec' \in \underline{S}$ such that $\underline{A} \prec\prec \underline{B}$ implies the existence of $\underline{C} \in \text{II}^X$ such that $\underline{A} \prec\prec' \underline{C} \prec\prec' \underline{B}$, (i. e. $\prec\prec \subseteq \prec\prec'^2$).

The pair [X, $\underline{S}$] is calledsyntopogenous intuitionistic fuzzy space.In case $\underline{S}$ consists of a singletopogenous intuitionistic fuzzy order it is called a simplesyntopogenous structure (topogenousintuitionistic fuzzy structure).If all topogenous intuitionistic fuzzy orders of an syntopogenousintuitionistic fuzzy structure $\underline{S}$ on X are perfect,it is called perfect syntopogenousintuitionistic fuzzy structure or (intuitionistic fuzzy syntopology),and the space [X, $\underline{S}$] is called syntopologicalintuitionistic fuzzy space.If all topogenousintuitionistic fuzzy orders of a syntopogenousintuitionistic fuzzy structure $\underline{S}$ on X are biperfect,it is calledbiperfectsyntopogenous intuitionistic fuzzy structure or (biperfectsyntopology).

Definition 2.18:[ ] Asyntopogenous intuitionistic fuzzy space [X, $\underline{S}$] is said to be:

(T_0)- space If for any intuitionistic fuzzy points(IFPs) $x^{(\alpha,\beta)}$, $y^{(\gamma,\delta)}$ with $x^{(\alpha,\beta)} \leq y^{(\gamma,\delta)c}$ there is $\prec\prec \in \underline{S}$ such that $x^{(\alpha,\beta)} \prec\prec y^{(\gamma,\delta)c}$ or $y^{(\gamma,\delta)} \prec\prec x^{(\alpha,\beta)c}$.

(T_1)- space If for any intuitionistic fuzzy points(IFPs) $x^{(\alpha,\beta)}$, $y^{(\gamma,\delta)}$ with $x^{(\alpha,\beta)} \leq y^{(\gamma,\delta)c}$ there is $\prec\prec \in \underline{S}$ such that $x^{(\alpha,\beta)} \prec\prec y^{(\gamma,\delta)c}$.

(T_2)- space If for any intuitionistic fuzzy points (IFPs) $x^{(\alpha,\beta)}$, $y^{(\gamma,\delta)}$ with $x^{(\alpha,\beta)} \leq {}^{c}y^{(\gamma,\delta)}$ there is $\prec\prec \in \underline{S}$ and $\underline{A} \in \text{II}^X$ such that $x^{(\alpha,\beta)} \prec\prec \underline{A} \prec\prec^{c}\, {}^{c}y^{(\gamma,\delta)}$.

($T_2^{\backslash}$)- spaceIf for any intuitionistic fuzzy points (IFPs) $x^{(\alpha,\beta)}$, $y^{(\gamma,\delta)}$ with $x^{(\alpha,\beta)} \leq {}^{c}y^{(\gamma,\delta)}$ there are $\prec\prec \in \underline{S}$ and $\underline{A}, \underline{B} \in \text{II}^X$ such that $\underline{A} \cap \underline{B} = \underline{0}$, $x^{(\alpha,\beta)} \prec\prec \underline{A}$ and ${}^{c}y^{(\gamma,\delta)} \prec\prec \underline{B}$.

3. Intuitionistic fuzzy filter

Definition 3.1: Let$\underline{\mathfrak{F}}$be a non-empty family ofintuitionistic fuzzy **sets** on X (IFSs), then $\mathfrak{F}$ is said to be anintuitionistic fuzzyfilter on X if it is satisfying the following:

1. $\underline{0} \notin \underline{\mathfrak{F}}$;

2.If$\underline{A}$, $\underline{B} \in \underline{\mathfrak{F}}$, then $\underline{A} \cap \underline{B} \in \underline{\mathfrak{F}}$;

3.If$\underline{A} \in \underline{\mathfrak{F}}and\underline{A} \subseteq \underline{B}$, then$\underline{B} \in \underline{\mathfrak{F}}$.

Definition 3.2: Let $\mathfrak{P}$be a non-empty family ofintuitionistic fuzzysetson X (IFSs), then $\mathfrak{P}$ is called anintuitionistic fuzzyfilter base if it is satisfying:

1. $\underline{0} \notin \underline{\mathfrak{P}}$;

2. If$\underline{A}$, $\underline{B} \in \underline{\mathfrak{P}}$, then $\underline{A} \cap \underline{B} \in \underline{\mathfrak{P}}$;

A family $\underline{\mathcal{L}}$ is called a sub baseof anintuitionistic fuzzyfilter base if it is nonempty and theof any finite numbers of elements of $\underline{\mathcal{L}}$ is not $\underline{0}$.

Lemma 3.3:(i) If $\underline{\mathcal{L}}$ is a sub base of anintuitionistic fuzzyfilter, then the family $\mathfrak{P}(\mathcal{L})$ consistingof allfinite intersections of the elements of $\underline{\mathcal{L}}$ is anintuitionistic fuzzyfilter base**.**

(ii) If$\mathfrak{P}$is anintuitionistic fuzzyfilter base,then the family $\underline{\mathfrak{F}}$ $(\underline{\mathfrak{P}})$ consisting of all IFSs$\underline{A}$ such that$\underline{A} \supseteq \underline{B}$ for some$\underline{B} \in \mathfrak{P}$ **is** anintuitionistic fuzzyfilter**.**

(iii) $\mathfrak{P}(\underline{\mathcal{L}})$ and $\underline{\mathfrak{F}}$ $(\underline{\mathfrak{P}})$ are uniquely determined$\underline{\mathcal{L}}$ and $\mathfrak{P}$ respectively.

Lemma 3.4:(1) Let $\{\underline{\mathfrak{F}}_\alpha : \alpha \in \Gamma\}$ be a family ofintuitionistic fuzzyfilters on a set X. Then:

i. $\bigcap_{\alpha\in\Gamma} \underline{\mathfrak{F}}_\alpha = \{\bigcap_{\alpha\in\Gamma} \underline{F}_\alpha : \underline{F}_\alpha \in \underline{\mathfrak{F}}_\alpha\}$ *is also* an intuitionistic fuzzyfilter on X.

ii. $\bigcup_{\alpha\in\Gamma} \underline{\mathfrak{F}}_\alpha = \{\bigcup_{\alpha\in\Gamma} \underline{F}_\alpha : \underline{F}_\alpha \in \underline{\mathfrak{F}}_\alpha\}$ *is also* an intuitionistic fuzzyfilter on X.

(2) $\underline{\mathfrak{P}_1}$ and$\underline{\mathfrak{P}_2}$be twointuitionistic fuzzyfilter bases.Then$\underline{\mathfrak{F}}(\underline{\mathfrak{P}_1}) \subseteq \underline{\mathfrak{F}}(\underline{\mathfrak{P}_2})$iff for any $\underline{B} \in \underline{\mathfrak{P}_1}$there exists$\underline{A} \in \underline{\mathfrak{P}_2}$such that$\underline{A} \subseteq \underline{B}$.

Theorem 3.5: Let$\underline{\mathfrak{F}}$be anintuitionistic fuzzyfilter on X, and Y$\subseteq$X.Then$\underline{\mathfrak{F}}$ **\Y= {**$\underline{F}$**\Y :** $\underline{F} \in \underline{\mathfrak{F}}$ **}is an** intuitionistic fuzzyfilter on Y if $\underline{F}\backslash Y \neq \underline{0}$ for every $\underline{F} \in \underline{\mathfrak{F}}$**.**

Proof:

Since$\underline{F}\backslash Y \neq \underline{0}$ for every $\underline{F} \in \underline{\mathfrak{F}}$, then $\underline{0} \notin \underline{\mathfrak{F}}\backslash Y$. Let $\underline{A}\backslash Y$, $\underline{B}\backslash Y \in \underline{\mathfrak{F}}\backslash Y$, then clearly $(\underline{A}\backslash Y) \cap (\underline{B}\backslash Y) = (\underline{A} \cap \underline{B})\backslash Y$. Since $\underline{\mathfrak{F}}$ is anintuitionistic fuzzyfilter, then$\underline{A} \cap \underline{B} \in \underline{\mathfrak{F}}$and hence $(\underline{A}\backslash Y) \cap (\underline{B}\backslash Y) \in \underline{\mathfrak{F}}\backslash Y$. Let $\underline{F} \in \underline{\mathfrak{F}}$ and $\underline{B} \in$ Ysuch that$\underline{F}\backslash Y \subseteq \underline{B}$. Choose anIFS$\underline{C} \in \text{II}^X$ such that$\underline{C}\backslash Y = \underline{B}$. Since$\underline{\mathfrak{F}}$ is anintuitionistic fuzzyfilter onX, then $\underline{C} \in \underline{\mathfrak{F}}$, and hence$\underline{C}\backslash Y = \underline{B} \in \underline{\mathfrak{F}}\backslash Y$.

Theorem 3.6: Let f: X→Y be a function and $\underline{\mathfrak{F}}$be anintuitionistic fuzzyfilter onX. Then $f(\underline{\mathfrak{F}}) = \{ f(\underline{F}) : \underline{F} \in \underline{\mathfrak{F}}\}$is an intuitionistic fuzzy basefilter on Y.

Proof:

(i) Suppose that $\underline{0} \in f(\underline{\mathfrak{F}})$, then there exist$\underline{F} \in \underline{\mathfrak{F}}$ such that $f(\underline{F}) = \underline{0}$ which imply $\underline{F} = \underline{0}$ which contradict with $\underline{0} \notin \underline{\mathfrak{F}}$.Hence $\underline{0} \notin f(\underline{\mathfrak{F}})$.

(ii) Let $f(\underline{A})$,$f(\underline{B}) \in f(\underline{\mathfrak{F}})$such that$\underline{A}$, $\underline{B} \in \underline{\mathfrak{F}}$, then $f(\underline{A} \cap \underline{B}) \subseteq f(\underline{A}) \cap f(\underline{B}) \in f(\underline{\mathfrak{F}})$. Hence $f(\underline{\mathfrak{F}})$ is an intuitionistic fuzzy basefilter on Y.

Theorem 3.7: Let f: X→Y be a surjection function and $\underline{\text{E}}$be anintuitionistic fuzzyfilteronY. Then $f^{-1}(\underline{\text{E}}) = \{f^{-1}(\underline{\text{G}}) : \underline{\text{G}} \in \underline{\text{E}}\}$is an intuitionistic fuzzy basefilter on X.

Proof:

Suppose that $\underline{0} \in f^{-1}(\underline{E})$, then by surjection there exist $\underline{0} \in \underline{E}$ which contradict with $\underline{0} \notin \underline{E}$. Hence $\underline{0} \notin f^{-1}(\underline{E})$.

(i) Let $f^{-1}(\underline{G}), f^{-1}(\underline{G}`) \in f^{-1}(\underline{E})$ such that $\underline{G}, \underline{G}` \in \underline{E}$.

Since $\underline{E}$ *is* an intuitionistic fuzzy filter then $\underline{G} \cap \underline{G}` \in \underline{E}$, so $f^{-1}(\underline{G}) \cap f^{-1}(\underline{G}`) = f^{-1}(\underline{G} \cap \underline{G}`) \in f^{-1}(\underline{E})$. Hence $f^{-1}(\underline{E})$ is an intuitionistic fuzzy basefilter on X.

Definition 3.8: Let $(X, \underline{\mathfrak{F}})$ and $(Y, \underline{E})$ be two intuitionistic fuzzy filters, then a function $f:(X, \underline{\mathfrak{F}}) \to (Y, \underline{E})$ is called intuitionistic fuzzy filter continuous w.r.t $(\underline{\mathfrak{F}}, \underline{E})$ if

$f^{-1}(\underline{G}) \in \underline{\mathfrak{F}}$ for every $\underline{G} \in \underline{E}$.

Proposition 3.9: (i) I f $f:(X, \underline{\mathfrak{F}}) \to (Y, \underline{E})$ and $g:(Y, \underline{E}) \to (Z, \underline{\mathcal{H}})$ are two intuitionistic fuzzy filters continuous functions, then the composition $gof:(X, \underline{\mathfrak{F}}) \to (Z, \underline{\mathcal{H}})$ is also intuitionistic fuzzy filter continuous.

If $f:(X, \underline{\mathfrak{F}}) \to (X, \underline{\mathfrak{F}})$ is an identity function, then f is intuitionistic fuzzy filters continuous.

I f $f:(X, \underline{\mathfrak{F}}) \to (\mathbf{Y}, \underline{\mathbf{E}})$ is intuitionistic fuzzy filters continuous function, and $Z \subseteq X$ such that $\underline{\mathfrak{F}} \setminus \mathbf{Z} \neq \underline{0}$ for any $\underline{F} \in \underline{\mathfrak{F}}$. Then the restriction $f \setminus Z:(Z, \underline{\mathfrak{F}} \setminus Z) \to (Y, \underline{E})$ is also intuitionistic fuzzy filter continuous.

Proof:

Straightforward.

4. Convergence of intuitionistic fuzzy filters in syntopogenous intuitionistic fuzzy space

Proposition 4.1: Consider a syntopogenous intuitionistic fuzzy space $[X, \underline{S}]$ and IFp $x^{(\alpha,\beta)}$ of X. Then the family $\underline{B}_{S(x(\alpha,\beta))} = \{\underline{B} \in \mathrm{II}^X : x^{(\alpha,\beta)} \prec\prec \underline{B}$ for a suitable $\prec\prec \in \underline{S}\}$ forms an intuitionistic fuzzy filter on X.

Proof:

(i) If $\underline{B} \in \underline{B}_{S(x(\alpha,\beta))}$, then there exist $\prec\prec \in \underline{S}$ such that $x^{(\alpha,\beta)} \prec\prec \underline{B}$ which implies that $x^{(\alpha,\beta)} \in \underline{B}$ i.e $\underline{B} \neq \underline{0}$.

(ii) Let $\underline{B}, \underline{B}` \in \underline{B}_{S(x(\alpha,\beta))}$, then there exist $\prec\prec$, $\prec\prec` \in \underline{S}$ such that $x^{(\alpha,\beta)} \prec\prec \underline{B}$ and $x^{(\alpha,\beta)} \prec\prec` \underline{B}`$. Since $\underline{S}$ is a syntopogenous intuitionistic fuzzy structure, then there exists $\prec\prec`` \in \underline{S}$ finer than $\prec\prec$ and $\prec\prec`$. Thus $x^{(\alpha,\beta)} \prec\prec`` \underline{B}$ and $x^{(\alpha,\beta)} \prec\prec`` \underline{B}`$ which implies that $x^{(\alpha,\beta)} \prec\prec`` \underline{B} \cap \underline{B}`$. Hence $\underline{B} \cap \underline{B}` \in \underline{B}_{S(x(\alpha,\beta))}$.

(iii) Let $\underline{A} \subseteq \underline{B}$ and $\underline{A} \in \underline{B}_{S(x(\alpha,\beta))}$, then there exists $\prec\prec \in \underline{S}$ such that $x^{(\alpha,\beta)} \prec\prec \underline{A} \subseteq \underline{B}$ which implies that $x^{(\alpha,\beta)} \prec\prec \underline{B}$ i. e $\underline{B} \in \underline{B}_{S(x(\alpha,\beta))}$.

Hence $\underline{B}_{S(x(\alpha,\beta))}$ is an intuitionistic fuzzy filter in X.

Definition 4.2: Let $[X, \underline{S}]$ be any syntopogenous intuitionistic fuzzy space, and $x^{(\alpha,\beta)}$ be any IFp of X. Then the intuitionistic fuzzy filter given in the previous proposition is called the intuitionistic fuzzy filter of neighborhood of $x^{(\alpha,\beta)}$ in $\underline{S}$.

Definition 4.3: Let $\underline{S}$ be a syntopogenous intuitionistic fuzzy structure on X, and let $\underline{\mathfrak{F}}$ be an intuitionistic fuzzy filter in X. We call $\underline{\mathfrak{F}}$ converges to an $x^{(\alpha,\beta)}$ in $\underline{S}$, denoted by $\underline{\mathfrak{F}} \to x^{(\alpha,\beta)}$ iff $\underline{B}_{S(x(\alpha,\beta))} \subseteq \underline{\mathfrak{F}}$. Also we call $x^{(\alpha,\beta)}$ the intuitionistic fuzzy limit point of the intuitionistic fuzzy filter $\underline{\mathfrak{F}}$.

In more general manner we give the following definition.

Definition 4.4: An IFp $x^{(\alpha,\beta)}$ in a syntopogenous intuitionistic fuzzy structure $\underline{S}$ is called an intuitionistic fuzzy cluster point of an intuitionistic fuzzy filter $\underline{\mathfrak{F}}$ iff $\underline{B} \cap \underline{F} \neq \underline{0}$ for every $\underline{B} \in \underline{B}_{S(x(\alpha,\beta))}$ and $\underline{F} \in \underline{\mathfrak{F}}$.

Corollary 4.5: From the above definition it follows that any intuitionistic fuzzy limit point of an intuitionistic fuzzy filter is an intuitionistic fuzzy cluster point of it.

Theorem 4.6: An IFpx $^{(\alpha,\beta)}$ in a syntopogenous intuitionistic fuzzy space [X, $\underline{S}$] is an intuitionistic fuzzy cluster point of an intuitionistic fuzzy filter $\underline{\mathfrak{F}}$ iff there exists an intuitionistic fuzzy filter $\underline{\mathfrak{F}}$\` in $\underline{S}$ which consists $\underline{\mathfrak{F}}$ and converges to x $^{(\alpha,\beta)}$ in $\underline{S}$.

Proof:

Let x $^{(\alpha,\beta)}$ be an intuitionistic fuzzy cluster point of the intuitionistic fuzzy filter $\underline{\mathfrak{F}}$ in a syntopogenous intuitionistic fuzzy space [X, $\underline{S}$], then $\underline{B} \cap \underline{F} \neq \underline{0}$ for every $\underline{B} \in \underline{B}_{S_{(x(\alpha,\beta))}}$ and $\underline{F} \in \underline{\mathfrak{F}}$, this follows that $\underline{B}_{S_{(x(\alpha,\beta))}} \cap \underline{\mathfrak{F}}$ is an intuitionistic fuzzy filter. Since $\underline{B} \supseteq \underline{B} \cap \underline{F}$ and $\underline{F} \supseteq \underline{B} \cap \underline{F}$ for every $\underline{B} \in \underline{B}_{S_{(x(\alpha,\beta))}}$ and $\underline{F} \in \underline{\mathfrak{F}}$. Also $\underline{B} \cap \underline{F} \in \underline{B}_{S_{(x(\alpha,\beta))}} \cap \underline{\mathfrak{F}}$.Then $\underline{B}$, $\underline{F} \in \underline{B}_{S_{(x(\alpha,\beta))}} \cap \underline{\mathfrak{F}}$ for every $\underline{B} \in \underline{B}_{S_{(x(\alpha,\beta))}}$ and $\underline{F} \in \underline{\mathfrak{F}}$. It follows that $\underline{\mathfrak{F}}$, $\underline{B}_{S_{(x(\alpha,\beta))}} \subseteq \underline{B}_{S_{(x(\alpha,\beta))}} \cap \underline{\mathfrak{F}}$. Hence $\underline{B}_{S_{(x(\alpha,\beta))}} \cap \underline{\mathfrak{F}}$ is an is an intuitionistic fuzzy filter includes $\underline{\mathfrak{F}}$ and converges to x $^{(\alpha,\beta)}$ in $\underline{S}$.

Conversely, Let $\underline{\mathfrak{F}}$\` be anintuitionistic fuzzy filter includes $\underline{\mathfrak{F}}$ and converges to x $^{(\alpha,\beta)}$ in $\underline{S}$. Then $\underline{\mathfrak{F}}$\` includes $\underline{B}_{S_{(x(\alpha,\beta))}}$. Also for every $\underline{F}$\` $\in \underline{\mathfrak{F}}$\` and $\underline{B} \in \underline{B}_{S_{(x(\alpha,\beta))}}$ imply $\underline{B}$, $\underline{F}$\` $\in \underline{\mathfrak{F}}$, then

$\underline{B} \cap \underline{F}$\` $\neq \underline{0}$. Hence x $^{(\alpha,\beta)}$ is anintuitionistic fuzzy cluster point of $\underline{\mathfrak{F}}$.

Corollary 4.7: Let $\underline{\mathfrak{F}}$ an d $\underline{\mathfrak{F}}$\` be two intuitionistic fuzzy filters in a syntopogenous intuitionistic fuzzy space [X, $\underline{S}$] and x $^{(\alpha,\beta)}$ be an IFpin $\underline{S}$.Then :

(i) $\underline{\mathfrak{F}}$\` $\supseteq \underline{\mathfrak{F}} \to$ x $^{(\alpha,\beta)}$ ($\underline{S}$) $\Rightarrow \underline{\mathfrak{F}}$\` $\to$ x $^{(\alpha,\beta)}$ ($\underline{S}$).

(ii) $\underline{\mathfrak{F}} \to$ x $^{(\alpha,\beta)}$ ($\underline{S}$) and $\underline{\mathfrak{F}}$\` $\to$ x $^{(\alpha,\beta)}$ ($\underline{S}$) $\Rightarrow \underline{\mathfrak{F}} \cup \underline{\mathfrak{F}}$\` $\to$ x $^{(\alpha,\beta)}$ ($\underline{S}$).

Proof: (i) If $\underline{\mathfrak{F}} \to$ x $^{(\alpha,\beta)}$ ($\underline{S}$), then $\underline{B}_{S_{(x(\alpha,\beta))}} \subseteq \underline{\mathfrak{F}} \subseteq \underline{\mathfrak{F}}$\`. Consequently $\underline{\mathfrak{F}}$\` $\to$ x $^{(\alpha,\beta)}$ ($\underline{S}$).

(ii) $\underline{\mathfrak{F}} \to$ x $^{(\alpha,\beta)}$ ($\underline{S}$) $\Rightarrow \underline{B}_{S_{(x(\alpha,\beta))}} \subseteq \underline{\mathfrak{F}}$, and $\underline{\mathfrak{F}}$\` $\to$ x $^{(\alpha,\beta)}$ ($\underline{S}$) $\Rightarrow \underline{B}_{S_{(x(\alpha,\beta))}} \subseteq \underline{\mathfrak{F}}$\` which imply $\underline{B}_{S_{(x(\alpha,\beta))}} \subseteq \underline{\mathfrak{F}} \cup \underline{\mathfrak{F}}$\`. Hence $\underline{\mathfrak{F}} \cup \underline{\mathfrak{F}}$\` $\to$ x $^{(\alpha,\beta)}$ ($\underline{S}$).

Theorem 4.8: A syntopogenous intuitionistic fuzzy space [X, $\underline{S}$] is **($T_2^{\backslash}$)-** space iff there is no intuitionistic fuzzy filter $\underline{\mathfrak{F}}$ which converges to two distinct IFps of [X, $\underline{S}$].

Proof:

Suppose that [X, $\underline{S}$] is **($T_2^{\backslash}$)-** space, and $\underline{\mathfrak{F}}$ is an intuitionistic fuzzy filter $\underline{\mathfrak{F}}$ which converges to two distinct IFpsx $^{(\alpha,\beta)}$, y $^{(\gamma,\delta)}$. Then $\underline{B}_{S_{(x(\alpha,\beta))}} \subseteq \underline{\mathfrak{F}}$ and $\underline{B}_{S_{(y(\gamma,\delta))}} \subseteq \underline{\mathfrak{F}}$ which implies $\underline{B}_{(\alpha,\beta)} \cap \underline{B}_{(\gamma,\delta)} \neq \underline{0}$ for every $\underline{B}_{(\alpha,\beta)} \in \underline{B}_{S_{(x(\alpha,\beta))}}$, $\underline{B}_{(\gamma,\delta)} \in \underline{B}_{S_{(y(\gamma,\delta))}}$. Consequently for every $\prec\prec$, $\prec\prec$\` $\in \underline{S}$ and for every IFSs $\underline{A}$, $\underline{B}$ with x $^{(\alpha,\beta)} \prec\prec \underline{A}$, y $^{(\gamma,\delta)} \prec\prec$\` $\underline{B}$ and $\underline{A} \cap \underline{B} \neq \underline{0}$ which contradict that [X, $\underline{S}$] is **($T_2^{\backslash}$)-** space.

Conversely;

Suppose that there is no intuitionistic fuzzy filter $\underline{\mathfrak{F}}$ which converges to two distinct IFps of [X, $\underline{S}$]. Let x $^{(\alpha,\beta)}$ and y $^{(\gamma,\delta)}$ be two IFps in X. For every $\underline{B}_{(\alpha,\beta)} \in \underline{B}_{S_{(x(\alpha,\beta))}}$, $\underline{B}_{(\gamma,\delta)} \in \underline{B}_{S_{(y(\gamma,\delta))}}$ such that $\underline{B}_{(\alpha,\beta)} \cap \underline{B}_{(\gamma,\delta)} \neq \underline{0}$ this implies the existence of intuitionistic fuzzy filter $\underline{\mathfrak{F}}$\` = $\underline{B}_{S_{(x(\alpha,\beta))}} \cap \underline{B}_{S_{(y(\gamma,\delta))}}$ includes $\underline{B}_{S_{(x(\alpha,\beta))}}$ and $\underline{B}_{S_{(y(\gamma,\delta))}}$ and converges to x $^{(\alpha,\beta)}$ and y $^{(\gamma,\delta)}$ which contradicts the hypothesis. So $\prec\prec$, $\prec\prec$\` $\in \underline{S}$ such that x $^{(\alpha,\beta)} \prec\prec \underline{\square}_{(\square,\square)}$, y $^{(\gamma,\delta)} \prec\prec$\` $\underline{\square}_{(\square,\square)}$ and $\underline{\square}_{(\square,\square)} \cap \underline{\square}_{(\square,\square)} = \underline{0}$. Hence [X, $\underline{S}$] is **($T_2^{\backslash}$)-** space.

Corollary 4.9: If [X, $\underline{S}$] is syntopogenous intuitionistic fuzzy space, such that there is no intuitionistic fuzzy filter □ which have two distinct IFcluster points. Then [X, $\underline{S}$] is (T_2)- space.

Proof:

Since ever IF limit point for an intuitionistic fuzzy filter is an IFcluster point of it. Then theorem 4.8 yield the proof.

Now we will define a kind of intuitionistic fuzzy filters in the syntopogenous intuitionistic fuzzy spaces which characterized by uniqueness of limit in the (T_2)syntopogenous intuitionistic fuzzy space.

Definition 4.10: We call an intuitionistic fuzzy filter(intuitionistic fuzzy filter base) □ a quasi-coincident iff $\underline{F}\ q\ \underline{F}'$ for every $\underline{F}, \underline{F}' \in$ □.

Definition 4.11: For every intuitionistic fuzzy filter (intuitionistic fuzzy filter base) the quasi-coincident part of □ is the maximal one of he set of quasi-coincidentintuitionistic fuzzy filter (intuitionistic fuzzy filter base) which contained in □.

Theorem 4.12: In anysyntopogenous intuitionistic fuzzy space [X, $\underline{S}$], the intuitionistic fuzzy filter of neighborhoods $□_{□(□(□,□))}$ is quasi-coincident if the values □ ≥ □ > $1/2$.

Proof:

Straightforward.

Corollary 4.13: Every convergent filter in any syntopogenous intuitionistic fuzzy space [X, $\underline{S}$] contains a quasi-coincident part if its IF limit point x $^{(\alpha,\beta)}$ satisfying □ ≥ □ > $1/2$.

Proof:

Straightforward.

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