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Intuitionistic Fuzzy λ – Closed Sets

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Abstract

In this paper, we introduce the concept of the intuitionistic fuzzy λ – closed set in intuitionistic fuzzy topological spaces and study some of its properties.

Keywords and Phrases: *Intuitionistic fuzzy topology, intuitionistic fuzzy λ – closed set, intuitionistic fuzzy λ – open set, intuitionistic fuzzy λ-irresolute mapping*

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INTRODUCTION

The concept of intuitionistic fuzzy sets and intuitionistic fuzzy set operations were first introduced by Atanassov in his classical paper [1].

The notion of intuitionistic fuzzy sets naturally plays a very significant role in the study of intuitionistic fuzzy topology introduced by Chang [2].

Subsequently several authors have applied various basic concepts from general topology to an intuitionistic fuzzy sets and developed the theory of intuitionistic fuzzy topological spaces.

Pu and Liu [3] introduced the concept of quasi – coincidence and q-neighbourhoods by which the extensions of mappings in an intuitionistic fuzzy set can very interestingly and effectively be carried out. The aim of this paper is to introduce the notion of intuitionistic fuzzy λ – closed sets, a new generalization of an intuitionistic fuzzy closed set in intuitionistic fuzzy topological spaces.

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PRILIMINARIES

A family τ of intuitionistic fuzzy sets of X is called an intuitionistic fuzzy topology [2] on X if $0_{\sim}$ &$1_{\sim}$ belong to τ and τ is closed with respect to arbitrary union and finite intersection. The members of τ are called intuitionistic fuzzy open sets and their complements are intuitionistic fuzzy closed sets.

Throughout this paper, (X,τ), (Y, σ) and (Z, γ) (or simply X, Y and Z) always mean intuitionistic fuzzy topological spaces on which no separation axioms are assumed unless otherwise mentioned.

For an intuitionistic fuzzy set A of (X, τ), Cl (A) and Int (A) denote the closure and the interior of A respectively. By $0_{\sim}$ &$1_{\sim}$ we will mean the intuitionistic fuzzy sets with constant function 0 (Zero function) and 1 (Unit function) respectively.

The following definitions are useful in the sequel.

Definition 1.1: [1] Let X be a non-empty fixed set. An Intuitionistic fuzzy set (IFS in short) A in X having the form A = {<x, μ_A (x), ν_A(x)>x∈X} where the functions μ_A:X→[0,1] and ν_A:X→[0,1] denote the degree of membership (namely μ_A(x)) and the degree of non-membership (namely ν_A(x)) of each element xϵX to the set A respectively and $0 \leq \mu_A + \nu_A \leq 1$ for each x∈X . Denote by IFS(X), the set of all intuitionistic fuzzy sets in X.

Definition 1.2: [1] Let A and B be IFS's of the form A = {<x, μ_A (x), ν_A(x)>x∈X} and B={<x,μ_B (x),ν_B(x)>x∈X}. TheN

1. A⊆B if and only if $\mu_A(x) \leq \mu_B(x)$ and $\nu_A(x) \geq \nu_B(x)$ for all x∈X
2. A=B if and only if A⊆B and B⊆A`
3. A^C= {<x, ν_A(x), μ_A(x)>x∈X}
4. A∩B= {<x, $\mu_A(x) \wedge \mu_B(x)$, $\nu_A(x) \vee \nu_B(x)$>x∈X
5. A∪B= {<x, $\mu_A(x) \vee \mu_B(x)$, $\nu_A(x) \wedge \nu_B(x)$>xϵX}

For the sake of simplicity, we shall use the notation A =<x, μ_A, ν_A>instead of A = {<x, μ_A(x), ν_A(x)>/x ϵX}. The intuitionistic fuzzy sets $0_{\sim}$ = {<x, 0, 1>x∈X} and $1_{\sim}$ = {<x, 1, 0>/ x ∈X} are respectively the empty set and the whole set of X

Definition 1.3 [28] An Intuitionistic Fuzzy Topology (IFT for short) on X is a family τ of IFSs in X satisfying the following axioms:

1. $0_{\sim}$, $1_{\sim}$ ⊆τ,
2. G1 ∩ G2 ∈τ,for any G_1,G_2∈τ,
3. ∪Gi∈τ for any family {G_i / i ∈J} ⊆τ.

In this case the pair (X, τ) is called an Intuitionistic Fuzzy Topological space

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(IFTS in short) and any IFS in τ is known as an Intuitionistic Fuzzy Open Set (IFOS in 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 1.4 [28]

Let (X, τ) be an IFTS and A =$\{<x, \mu_A, \nu_A>x \in X\}$ be an IFS in X.Then the intuitionistic fuzzy interior and intuitionistic fuzzy closure are defined by

1. int(A) = ∪{G : G is an IFOS in X and G ⊆A},

2. cl(A) = ∩{K : K is an IFCS in X and A ⊆ K} .

3. $cl(A^c)=(int(A))^c$

4. $int(A^c)=(cl(A))^c$.

Definition 1.5:

An IFS A = $\{<x, \mu_A, \nu_A>x \in X\}$ in an IFTS (X, τ) is said to be an

(i) Intuitionistic Fuzzy Semiclosed Set (IFSCS for short) if (int(cl(A)) ⊆A,

(ii) Intuitionistic Fuzzy Preclosed Set (IFPCS for short) if (cl(int(A)) ⊆A,

(iii) Intuitionistic Fuzzy Regular Closed Set (IFRCS for short) if A = (cl(int(A)),

(iv) Intuitionistic Fuzzy α Closed Set (IFαCS for short) if (cl(int(cl(A))) ⊆A,

(v) Intuitionistic Fuzzy β Closed Set (IF β CS for short) if (int(cl(int(A))) ⊆A,

(vi) Intuitionistic Fuzzy Q-Set(IFQ-set for short) if (int(cl(A)) ⊆ (cl(int(A))

An IFS A is said to be an intuitionistic fuzzy semi-closed set (IFSCS), intuitionistic fuzzy pre closed set (IFPCS), intuitionistic fuzzy α-Closed Set (IFαCS), intuitionistic Fuzzy β Closed Set (IFβCS), intuitionistic Fuzzy Regular Closed Set (IFRCS) if the complement of A in an IFSOS, IFPOS, IFαOS, IFβOS, IFROS respectively.

Definition 1.6: An IFS A in an IFTS (X, τ) is an

(i) Intuitionistic Fuzzy Generalized Closed Set (IFGCS for short) if cl(A) ⊆U,whenever A⊆U and U is an IFOS in X ,

(ii) Intuitionistic Fuzzy w-Closed Set (IFWCS for short) if cl(A) ⊆U,whenever A ⊆U and U is an IFSOS in X .

(iii) Intuitionistic Fuzzy Semi-generalized Closed Set (IFSGCS for short) if scl(A) ⊆U whenever A ⊆U and U is an IFSOS .

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(iv) Intuitionistic Fuzzy Regular Generalized Closed Set (IFRGCS for short) if cl(A) ⊆U whenever A ⊆U and U is an IFROS .

v) Intuitionistic Fuzzy Generalised α Closed set (IFGαCS) if αcl(A)⊆U whenever A⊆U and U is an IFαOS in X.

vi) Intuitionistic Fuzzy Generalized Semi-Pre Closed set (IFGSPCS for short) if spcl(A)⊆U whenever A⊆U and U is an IFOS in (X, τ)

The compliment of IFGCS (respectively IFWCS, IFSGCS and IFRGCS) is called IFGOS (respectively IFWOS, IFSGOS and IFRGOS).

Definition 1.7: Let α, β ∈[0, 1] with α + β≤ 1. An Intuitionistic Fuzzy point (IFP for short), written as p(α,β), is defined to be an IFS of X given by

$$p(\alpha,\beta)(x)=\begin{cases}(\alpha,\beta) & \text{if } x=p\\ (0,1) & \text{otherwise}\end{cases}$$

We observe that an IFP p(α,β) is said to belong to an IFS A = {<x, μ_A, ν_A>x∈X} denoted by p(α,β) ∈A if α ≤ $\mu_{A(X)}$, and β ≥ $\nu_{A(X)}$.

Definition 2.1:

An intuitionistic fuzzy set A of (X, τ) is called:

1. Intuitionistic fuzzy generalized closed (briefly, IFG – closed) if Cl (A) ⊆ U, whenever A ⊆ U and U is intuitionistic fuzzy open set in X.

2. Intuitionistic fuzzy gλ – closed (briefly, IFGλ – closed) if Cl (A) ⊆ U and U is intuitionistic fuzzy gλ – open set in X.

3. Intuitionistic fuzzy regular generalized closed set (briefly, IfRG – closed) if Cl (A) ⊆ U, whenever A ⊆ U and U is intuitionistic fuzzy regular open set in X.

Definition 2.2: Two intuitionistic fuzzy sets A and B are said to be q-coincident(A_qB in short) if and only if there exists an element x∈ X such that $\mu_{A(X)}>\nu_{B(X)}$or $\nu_{A(x)}<\mu_{B(x)}$.

Definition 2.3: Two intuitionistic fuzzy sets are said to be not q-coincident (Aq^c B in short) if and only if A $\subseteq B^c$.

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INTUITIONISTIC FUZZYλ – CLOSED SETS

Definition 3.1: An intuitionistic fuzzy set A of intuitionistic fuzzy topological spaces (X, τ) is called an intuitionistic Fuzzyλ – closed set [in short IF λ – closed] if Cl (A) ⊆ U whenever A ⊆ U and U is an intuitionistic fuzzy g* – open.

Theorem 3.2: Every intuitionistic fuzzy closed set is an intuitionistic fuzzy λ – closed sets.

Proof: Let A is an intuitionistic fuzzy closed set of topological space (X, τ) then A = Cl (A). Now we have to prove that A is an intuitionistic fuzzy λ – closed set. Let A ⊆ U and U is an intuitionistic fuzzy g – open which implies that Cl (A) ⊆ U since A = Cl (A) therefore Cl (A) ⊆ U whenever A ⊆ U and U is an intuitionistic fuzzy g* – open. Hence A is an intuitionistic fuzzy λ – closed set.

Remark 3.3: The converse of above theorem need not be true as seen from the following example.

Example 3.4: Let X = {a, b} and G = < x, (0.6, 0.7) (0.4, 0.3)}. Then τ = {0, G, 1} is an IFT on X and the IFS A = {x, (0.1, 0.1) (0.9, 0.9)} is an IFλ CS but not an IFCS in (X, τ).

Theorem 3.5: If an intuitionistic fuzzy set A of an intuitionistic topological space (X, τ) is both an intuitionistic fuzzy open and intuitionistic fuzzy λ – closed set.

Proof: Suppose a intuitionistic fuzzy set A of intuitionistic fuzzy topological space (X, τ) is both an intuitionistic fuzzy open and intuitionistic fuzzy λ – closed set. Since every intuitionistic fuzzy open set is g – open set, therefore A is an intuitionistic fuzzy g – open set of an intuitionistic fuzzy topological space (X, τ) such that A ⊆ A. Now A is an intuitionistic fuzzy λ – closed set of topological space (X, τ) then by definition of intuitionistic fuzzy λ-closed set we have Cl (A) ⊆ A. Since A ⊆ Cl (A) for every intuitionistic fuzzy set A. Therefore Cl (A) = A. Thus A is an intuitionistic fuzzy closed set in intuitionistic fuzzy topological space (X, τ).

Theorem 3.6: Every intuitionistic fuzzy g* – closed set is intuitionistic fuzzy λ – closed set.

Proof: Let A is an intuitionistic fuzzy g* – closed set of intuitionistic fuzzy topological space (X, τ). We have to prove that A is an intuitionistic fuzzy λ – closed set. Let A ⊆ U and U is an intuitionistic fuzzy g* – open. Since U is an

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intuitionistic fuzzy g* – open such that A ⊆ U. Then by definition of intuitionistic fuzzy g* – closed set Cl (A) ⊆ U whenever A ⊆ U and U is g* – open. Hence A is an intuitionistic fuzzy λ – closed set.

Remark 3.7: The converse of the above theorem need not to be true as seen from the following example.

Example 3.8: Let X = {a, b} and G = < x, (0.7, 0.8) (0.3, 0.2)}. Then τ = {0, G, 1} is an IFT on X and the IFS A = {x, (0.2, 0.2) (0.8, 0.8)} is an IFλ CS but not an IFg*CS in (X, τ).

Theorem 3.9: If a subset A of topological space (X, τ) is both intuitionistic fuzzy open and intuitionistic fuzzy λ – closed then it is g* – closed set.

Proof: Suppose intuitionistic fuzzy set A of topological space (X, τ) is both intuitionistic fuzzy open and intuitionistic fuzzy λ – closed set. Since every intuitionistic fuzzy open set is intuitionistic g – open set, therfore A is an intuitionistic fuzzy g – open subset of topological space (X, τ) such that A ⊆ A. Now A is a λ – closed set of intuitionistic fuzzy topological space (X, τ) then Cl (A) ⊆ A. Therefore Cl (A) ⊆ Awhenever A ⊆ A and A is an intuitionistic fuzzy g – open in (X, τ). Thus A is an intuitionistic fuzzy g* – closed set in intuitionistic fuzzy topological space (X,τ).

Theorem 3.10: Every intuitionistic fuzzy λ – closed set A of topological space (X, τ) is an intuitionistic fuzzy g– closed set.

Proof: Let A is intuitionistic fuzzy λ – closed set of topological space. We have to prove that A is an intuitionistic fuzzy g – closed sets in (X, τ). Let A ⊆ U and U is open subset of X. Since every open set is g – open, U is a g – open set of X. Now A is λ – closed set of topological space (X, τ) then by definition of λ – closed set we have Cl(A) ⊆ U we have Cl (A) ⊆ U whenever A ⊆ U and U is – open in (X, τ). Thus A is g – closed set in topological space (X,τ).

Remark 3.11: The converse of the above theorem need not be true as seen from the following example.

Example 3.12: Let X = {a, b} and G = < x, (0.7, 0.7) (0.3, 0.2)}. Then τ = {0, G, 1} is an IFT on X and the IFS A = {x, (0.7, 0.6) (0.3, 0.4)} is an IFGCS but not an IF λ CS in (X, τ).

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Theorem 3.13: Every intuitionistic fuzzy λ – closed set A of topological space (X, τ) is intuitionistic fuzzy rg – closed set.

Proof: Let A is an intuitionistic fuzzy λ – closed set of topological space. We have to prove that A is an intuitionistic fuzzy rg – closed sets in (X, τ).Let A ⊆ U and U is regular open subset of X. Since every intuitionistic fuzzy regular open set is intuitionistic fuzzy open set and every intuitionistic fuzzy open set is intuitionistic fuzzy g – open. U is an intuitionistic fuzzy g – open set of X. Now A is an intuitionistic fuzzy λ – closed set of topological space (X, τ) then by definition of intuitionistic fuzzy λ – closed set we have Cl (A) ⊆ U. Therfore Cl (A) ⊆ U whenever A ⊆ U and U is an intuitionistic fuzzy regular open in (X, τ).

Thus A is an intuitionistic fuzzy rg – closed set in topological space (X, τ).

Remark 3.14: The converse of the above theorem need not be trueas seen from the following example.

Example 3.15: Let X = {a, b} and G = < x, (0.8, 0.8) (0.2, 0.1)}. Then τ = {0, G, 1} is an IFT on X and the IFS A = {x, (0.9, 0.7) (0.1, 0.3)} is an IFRGCS but not an IF λ CS in (X, τ).

Remark 3.16: Theorem 3.2, 3.6, 3.10, and 3.13 reveals the following diagram of implications.

IFR-closed set

IFg*-closed setIFG-closed set

IFRG-closed set

IF-closed set IFλ-closed set

Theorem 3.17: An intuitionistic set A of intuitionistic fuzzy topological space (X, τ) is an intuitionistic fuzzy λ – closed if and only if ד A q B ⇒ד Cl (A) qB for every intuitionistic fuzzy g* – closed set of B of X.

Proof: Suppose that A is an intuitionistic fuzzy λ – closed set of X such that ד A q B Then A $\subseteq B^c$ and B^c is an intuitionistic fuzzy g* – open set X. which implies that Cl (A) $\subseteq B^c$ since A is an intuitionistic fuzzy λ – closed. Hence ד Cl (A) qB.

Conversely, Let U be an intuitionistic fuzzy g* – open set in X such that A ⊆ U. Then ד A q U^c and U^c is an intuitionistic fuzzy g* – closed set in X. Then by hypothesis ד Cl (A) q U^c which implies that Cl (A) ⊆ U. Hence A is an intuitionistic fuzzy λ – closed set.

Theorem 3.18: If A is an intuitionistic fuzzy λ – closed set in an intuitionistic

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fuzzy topological space (X, τ) and A ⊆ B ⊆ Cl (A), then B is an intuitionistic fuzzy λ −closed set in intuitionistic fuzzy topological sapce (X, τ).

Proof: Let A be an intuitionistic fuzzy λ – closed set in an intuitionistic fuzzy topological space (X, τ) Let B ⊆ U where U is an intuitionistic fuzzy g* – open set in X. Then A ⊆ U. Since A is an intuitionistic fuzzy λ – closed set, it follows that Cl (A) ⊆ U. Now B ⊆ Cl (A) which implies that Cl (B) ⊆ Cl (A) ⊆ U. Hence B is an intuitionistic fuzzy λ – closed set in X.

Definition 3.19: An intuitionistic fuzzy set A of an intuitionistic fuzzy topological space (X, τ) is said to be an intuitionistic fuzzy λ – open set in A if its complement A^c is an intuitionistic fuzzy λ – closed.

Theorem 3.20: Every intuitionistic fuzzy open set is an intuitionistic fuzzy g* – open.

Proof: Let A is an intuitionistic fuzzy open set in an intuitionistic fuzzy topological space (X, τ). Then A^c is an intuitionistic fuzzy closed set in an intuitionistic fuzzy topological space (X, τ).

Now by theorem 3.2. Every intuitionistic fuzzy closed set is an intuitionistic fuzzy λ – closed. Therefore A^c is an intuitionistic fuzzy λ – closed set. Hence by definition 4.1 A is an intuitionistic fuzzy λ – open set in (X, τ).

Theorem 3.21: Every intuitionistic fuzzy g* – open set is fuzzy λ – open.

Proof: Let A is an intuitionistic fuzzy g* – open set in topological space (X, τ). Then A^c is an intuitionistic fuzzy g* – closed set in an intuitionistic fuzzy topological space (X, τ).

Now by theorem 3.3 every intuitionistic fuzzy g* – closed set in an intuitionistic fuzzy λ – closed. Therefore A^c is an intuitionistic fuzzy λ – closed set. Hence by definition 4.1 A is an intuitionistic fuzzy λ – open set in (X, τ).

Theorem 3.22: A set A of an intuitionistic fuzzy topological space (X, τ) is an intuitionistic fuzzy λ – open if and only if F ⊆ Cl (A) whenever F is an intuitionistic fuzzy g* – closed and F ⊆ A.

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Proof: Necessity: Let A is an intuitionistic fuzzy λ – open set. F is an intuitionistic fuzzy g* – closed set such that F ⊆ A. Then F^c is g* – open set such that $A^c \subseteq F^c$. Now by hypothesis A^c is an intuitionistic fuzzy λ – closed set. We have Cl $((A^c)) \subseteq F^c$ which implies that F ⊆ Cl ((A)).

Sufficiency: Let F ⊆ Cl (A) whenever F is g* – closed and F ⊆ A. We have to prove that A is an intuitionistic fuzzy λ – open set. Let U is an intuitionistic fuzzy g* – open set of X such that $A^c \subseteq$ U. Then U^c is an intutionistic fuzzy g*– closed set such that $U^c \subseteq$ A. Therefore by hypothesis $U^c \subseteq$ Cl (A) which implies that Cl $(A)^c \subseteq$ U we have Cl $((A^c)) \subseteq$ U where $A^c \subseteq$ U and U is an intuitionistic fuzzy g* – open. Hence A^c is an intuitionistic fuzzy λ – closed. Thus A is an intuitionistic fuzzy λ – open.

Theorem 3.23: Let A is an intuitionistic fuzzy λ – closed set of X and int((A)) ⊆ B ⊆ A. Then B is an intuitionistic fuzzy λ – open set.

Proof: Let A is an intuitionistic fuzzy λ – open set in X. such that int (A) ⊆ B ⊆ A which implies that $A^C \subseteq B^c \subseteq$ (int$(A)^c$ = Cl (A^c) Now A^c is an intuitionisticλ – closed set such that $A^c \subseteq B^c \subseteq$ Cl (A^c)) Then by theorem 3.7 B^c is an intuitionistic fuzzy λ – closed set. Hence B is an intuitionistic fuzzy λ – open set.

CONCLUSION

The theory of g – closed sets plays an important role in general topology. Since its inception many weak and strong forms of g – closed sets have been introduced in general topology as well as intuitionistic fuzzy topology. The present paper investigated a new weak form of intuitionistic fuzzy g – closed sets called intuitionistic fuzzy λ – closed sets which contain the classes of intuitionistic fuzzy closed sets and intuitionistic fuzzy g* – closed sets and contained in the classes of intuitionistic fuzzy g – closed sets and intuitionistic fuzzy rg – closed sets. Several properties and applications of intuitionistic fuzzy λ – closed sets are studied. Many examples are given to justify the result.

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