On Intuitionistic Fuzzy Multi Generalized Pre-Closed Set

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ABSTRACT
The purpose of this paper is to introduce and study the concept of Intuitionistic fuzzy multi generalized pre-closed set and Intuitionistic fuzzy multi generalized pre-open set in Intuitionistic fuzzy multi topological space and investigate some of its properties.

Keywords
Intuitionistic fuzzy multi topology, Intuitionistic fuzzy multi generalized pre closed set, Intuitionistic fuzzy multi generalized pre open set.

1. INTRODUCTION
Fuzzy set(FS),proposed by Lofti A.Zadeh[1] in 1965,in which membership function assigns for each member of the universe of discourse.Krassimir.T.Atanassov[2] introduced the concept of Intuitionistic fuzzy set (IFS) in 1983 by introducing a non membership function together with the membership function of the fuzzy set. Then R.R.Yager [6] introduced the concept of fuzzy multi set which are useful for handling Problems With multi dimensional characterization properties and T.V.Ramakrishnan and S.Sabu[9] proposed fuzzy multi sets in 2010.In 1991, A.S.Binshahan[11] introduced and investigated the notations of fuzzy pre-open and fuzzy pre-closed sets in 2003, T.Fukutake, R.K.Saraf, M.Caldas and S.Mishra introduced fuzzy generalized pre-closed sets in fuzzy topological space.T.Shinoj and sunil Jacob john[10] proposed Intuitionistic fuzzy multi set (IFMS) in 2012 which is the combination of intuitionstic fuzzy set and fuzzy multi set. P.Rajarajeswari and Krishnamoorthy [11] introduced the concept of Intuitionistic fuzzy weakly generalized closed set. In this paper, Intuitionistic fuzzy multi weakly generalized closed set is introduced which is the combination of Intuitionistic fuzzy weakly generalized closed set and fuzzy multisets

2. PRELIMINARIES
Definition 2.1:[1]Let X be a non empty set.A Fuzzy set(FS in short) A drawn from X is defined as $A =\{ <x, \mu_A(x) > x \in X\}$ where the functions $\mu_A(x) : X \rightarrow [0,1]$ denote the degree of membership function.

Definition 2.2:[2]Let X be a non empty set. An Intutionistic fuzzy set (IFS in short) A in X is an object having the form

$A =\{ <x, \mu_A(x), \nu_A(x) > / x \in X\}$ where $\mu_A(x) : X \rightarrow [0,1]$ and $\nu_A(x) : X \rightarrow [0,1]$ denote the degree of membership and the degree of non membership of each element $x \in X$ in the set A respectively and $0 \leq \mu_A(x)+\nu_A(x) \leq 1$ for each $x \in X$.

Definition 2.3:[6]Let X be a non empty set.A Fuzzy multiset (FMS in short)A drawn from X is characterized by a function 'count membership' of A denoted by $CM_A : X \rightarrow Q$ where Q is the set of all crisp multiples drawn from the unit interval [0,1]. For each $x \in X$ the membership sequence is defined as $(\mu_A^1(x), \mu_A^2(x)\ldots\ldots\ldots \mu_A^p(x))$.

Definition 2.4:[10]Let X be a non empty set.An Intuitionistic fuzzy multi set(IFMS) A drawn from X is characterized by a function 'count membership' of A (CM_A) denoted by $CM_A : X \rightarrow Q$ and'count non membership' of A denoted by $CA_N : X \rightarrow Q$ where Q is the set of all crisp multiples drawn from the unit interval [0,1]. For each $x \in X$ the membership sequenc is defined as $(\mu_A^1(x), \mu_A^2(x)\ldots\ldots\ldots \mu_A^p(x))$ and corresponding non membership sequence denoted by $(\nu_A^1(x) ,\nu_A^2(x)\ldots.\nu_A^p (x))$ such that $0\leq\mu_A^i(x) + \nu_A^i (x) \leq 1$ for each $x \in X$ and $i=1,2\ldots p$. An IFMS is denoted by

$A =\{ <x, (\mu_A^1(x), \mu_A^2(x)\ldots\ldots\ldots \mu_A^p(x),$
$(\nu_A^1(x) , \nu_A^2(x)\ldots\ldots\nu_A^p (x)) > / x \in X\}.$

Definition 2.5:[10]Let A and B be two IFMS of the form

$A =\{ <x, (\mu_A^1(x), \mu_A^2(x)\ldots\ldots\ldots \mu_A^p(x)),$
$(\nu_A^1(x) , \nu_A^2(x)\ldots\ldots\nu_A^p (x)) > / x \in X\},$

$B =\{ <x, (\mu_B^1(x), \mu_B^2(x)\ldots\ldots\ldots \mu_B^p(x)),$
$(\nu_B^1(x) , \nu_B^2(x)\ldots\ldots\nu_B^p (x)) > / x \in X\},$

a) $A\subseteq B$ if and only if $\mu_A^j(x)\leq\mu_B^j(x)$ and $\nu_A^j (x) \geq \nu_B^j (x)$ for all $x \in X$,

b)A=B if and only if $A\subseteq$ and $B\subseteq A$,

c)$A^C =\{ <x, (\nu_A^1(x) , \nu_A^2(x)\ldots\ldots\nu_A^p (x)) ,$
$(\mu_A^1(x), \mu_A^2(x)\ldots\ldots\ldots \mu_A^p(x))> / x \in X\},$

d)$A\cup B=\{<x, \max (\mu_A^j(x) , \mu_B^j(x)),$
$\min(\nu_A^j(x) ,\nu_B^j(x)) > /x \in X\},$

e) $A\cap B=\{<x, \min (\mu_A^j(x) , \mu_B^j(x)),$
$\max (\nu_A^j(x) , \nu_B^j(x)) > / x \in X\}.$

The Intuitionistic fuzzy multi sets $0_{\sim}= \{ <x, 0, 1 > / x \in X\}$and $1_{\sim}=\{ <x,1,0 > / x \in X\}$ are respectively the empty set and the whole set.

Definition 2.6: An Intuitionistic fuzzy multi topology (IFMT in short) on a non empty set X is a Family τ of IFMS 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 $\{G_i / i \in J\} \subseteq \tau$.

In this case the pair (X, τ) is called an Intuitionistic fuzzy multi topological space(IFMTS in short) and any IFMS in τ is known as an Intuitionistic fuzzy multi open set(IFMOS) in X.

Definition 2.7: Let (X,τ) be an IFMTS and

$A = \{< x, (\mu_A^1, \mu_A^2 \ldots\ldots\ldots\ldots \mu_A^p),(\nu_A^1, \nu_A^2 \ldots\ldots \nu_A^p) > \}$ be an IFMS in X. Then the Intuitionistic fuzzy multi interior and an Intuitionistic fuzzy multi closure are defined by

$int(A) = \cup\{G / G$ is an IFMOS in X and $G \subseteq A\}$,

$cl(A) = \cap\{K / K$ is an IFMCS in X and $A \subseteq K\}$.

Result 2.8: Let A and B be two Intuitionistic fuzzy multi sets of an Intuitionistic fuzzy multi topological space (X ,τ).

a) A is an Intuitionistic fuzzy multi closed set in X $\Leftrightarrow cl(A) = A$,
b) A is an Intuitionistic fuzzy multi open set in X $\Leftrightarrow int(A) = A$

Definition 2.9: Let (X,τ) be an IFMTS and

$A = \{< x, (\mu_A^1, \mu_A^2 \ldots\ldots\ldots\ldots \mu_A^p),(\nu_A^1, \nu_A^2 \ldots\ldots \nu_A^p) > \}$ be an IFMS in X .Then alpha multi interior of A and alpha multi closure of A are defined by

$\alpha int(A) = \cup\{G / G$ is an IFMαOS in X and $G \subseteq A\}$,

$\alpha cl (A) = \cap\{K / K$ is an IFMαCS in X and $A \subseteq K\}$.

Result 2.10: Let A be an IFMS in (X,τ), then

$\alpha cl(A)=A \cup cl(int(cl(A)))$,

$\alpha int(A)= A \cap int(cl(int(A)))$.

Definition 2.11: Let A be an IFMS of the form

$A =\{ <x, (\mu_A^1(x), \mu_A^2(x) \ldots\ldots\ldots\ldots \mu_A^p(x)),$

$(\nu_A^1(x) , \nu_A^2(x) \ldots\ldots \nu_A^p (x)) > / x \in X\}$ in IFMTS (X ,τ) is called an

a) Intuitionistic fuzzy multi semi closed set (IFMSCS) if $int(cl(A)) \subseteq A$,

b) Intuitionistic fuzzy multi α closed set (IFMαCS) if $cl(int(cl(A))) \subseteq A$,

c) Intuitionistic fuzzy multi pre closed set (IFMPCS) if $cl(int(A)) \subseteq A$,

d) Intuitionistic fuzzy multi regular closed set (IFMSCS) if $cl(int(A)) = A$,

e) Intuitionistic fuzzy multi generalized closed set (IFMGCS) if $cl(A) \subseteq U$ whenever $A \subseteq U$ and U is an IFMOS

f)Intuitionistic fuzzy multi α generalized closed set (IFMαCS) if $\alpha cl(A) \subseteq U$whenever $A \subseteq U$ and U is an IFMOS.

An IFMS A is called Intuitionistic fuzzy multi semi open set, Intuitionistic fuzzy multi α open set, Intuitionistic fuzzy multi pre open set, Intuitionistic fuzzy multi regular open set, Intuitionistic fuzzy multi generalized open set, Intuitionistic fuzzy multi generalized semi open set, Intuitionistic fuzzy multi α generalized open set (IFMSOS, IFMαOS, IFMPOS, IFMROS, IFMGOS, IFMGSOS, IFMαOS) if the complement A^c is an IFMSCS, IFMαCS, IFMPCS, IFMRCS, IFMGCS, IFMGSCS and IFMαCS respectively.

3. INTUITIONISTIC FUZZY MULTI GENERALIZED PRE-ClOSED SET

In this section we introduce intuitionistic fuzzy multi generalized pre-closed set and studied some of its properties.

Definition 3.1: An IFMS A in an IFMTS (X,τ) is said to be an intuitionistic fuzzy multi generalized pre-closed set (IFMGPCS) in (X, τ) if $pcl(A) \subseteq U$ whenever $A \subseteq U$ and U is an IFMOS in X.

The family of all IFMGPCSs of an IFMTS (X,τ) is denoted by IFMGPCS(X).

Example 3.2: Let $X=\{a,b\}$ and let $\tau=\{0_\sim ,T , 1_\sim\}$ be an IFMT on X,where p=2.Then

$T =<x,(0.2,0.3),(0.3,0.4) , (0.5,0.3),(0.2,0.4)>$.Then the IFMS

$A=<x,(0.2,0.2),(0.3,0.4) , (0.6,0.3),(0.4,0.5)>$ is an IFMGPCS in X.

Theorem 3.3:Every IFMCS is an IFMGPCS but not conversely.

Proof: Let A be an IFMCS in X and let $A \subseteq U$ and U be an intuitionistic fuzzy multiopen set in(X, τ) since $pcl(A) \subseteq cl(A)$ and A is an IFMCS in X,$pcl(A) \subseteq cl(A)=A \subseteq U$. Therefore A is an IFMGPCS in X.

Example 3.4: Let $X=\{a,b\}$ and let $\tau=\{0_\sim ,T , 1_\sim\}$ be an IFMT on X where p=2,Then

$T=<x,(0.2,0.4),(0.6,0.2) , (0.4,0.3),(0.3,0.4)>$ and $A=<x,(0.2,0.1),(0.3,0.2) , (0.4,0.5),(0.6,0.4)>$ is an IFMGPCS but not an IFMCS in X since $cl(A)=T^c \neq A$.

Example 3.4: Let $X=\{a,b\}$ and let $\tau=\{0_\sim ,T , 1_\sim\}$ be an IFMT on X where p=2,Then

$T=<x,(0.2,0.4),(0.6,0.2) , (0.4,0.3),(0.3,0.4)>$ and $A=<x,(0.2,0.1),(0.3,0.2) , (0.4,0.5),(0.6,0.4)>$ is an IFMGPCS but not an IFMCS in X since $cl(A)=T^c \neq A$.

Theorem 3.5:Every IFMαCS is an IFMGPCS but not conversely.

Proof:Let A be an IFMαCS in X. Let $A \subseteq U$ and U be an intuitionistic fuzzy multi open set in (X,τ). By hypothesis, $cl(int(cl(A)) \subseteq A$. since $A \subseteq cl(A)$, $cl(int(A)) \subseteq cl(int(cl(A)) \subseteq A$. Hence $pcl(A) \subseteq A \subseteq U$. Therefore A is an IFMGPCS in X.

Example 3.6: Let $X=\{a,b\}$ and let $\tau=\{0_\sim ,T , 1_\sim\}$ be an IFMT on X where p=2,Then

$T=<X,(0.3,0.3),(0.6,0.7) , (0.6,0.5),(0.3,0.2)>$ and $A=<x,(0.2,0.3),(0.6,0.7) , (0.7,0.6),(0.4,0.3)>$ is an IFMGPCS in X but not an IFMαCS in X since $A \subseteq T$ but

$cl(int(cl(A) = <x,(0.6,0.5),(0.3,0.2) ,(0.3,0.3),(0.6,0.7)> \not\subseteq A$.

Theorem 3.7: Every IFMGCS is an IFMGPCS but not conversely.

Proof: Let A be an IFMGCS in X and let $A \subseteq U$ and U is an IFOS in (X,τ). Since $pcl(A) \subseteq cl(A)$ and by hypothesis, $pcl(A) \subseteq U$. Therefore A is an IFMGPCSin X.

Example 3.8: Let X={a,b} and let τ={0~ ,T , 1~} be an IFMT on X where p=2,Then

T=<X,(0.4,0.4),(0.5,0.3) , (0.4,0.5),(0.3,0.3)> and

A= < x,(0.3,0.4),(0.2,0.3) , (0.7,0.6),(0.8,0.4)> is an IFMGPCS in X but not an IFMGCS in X since A ⊆T but cl(A)= < x,(0.4,0.5),(0.3,0.3) , (0.4,0.4),(0.5,0.3)> ⊄ T.

Theorem 3.9:Every IFMRCS is an IFMGPCS but not conversely.

Proof: Let A be an IFMRCS in X. Let A ⊆U and U be an intuitioistic fuzzy multi open set in (X,τ).Since A is IFMRCS,

cl(int(A)) =A ⊆U. This implies cl(int(A))⊆U. Hence A is an IFMGPCS in X.

Example 3.10: Let X= {a,b } and let τ= {0~ ,T , 1~} be an IFMT on X where p=2 ,Then

T=< x,(0.4,0.3),(0.5,0.6) , (0.5,0.4),(0.4,0.3)> and

A=< x,(0.3,0.2),(0.4,0.3) , (0.7,0.6),(0.5,0.4)> is an IFMGPCS in X but not an IFMRCS in X since A⊆T but cl(int(A)) = 0 ≠ A.

Theorem 3.11:Every IFMαGCS is an IFMGPCS but not conversely.

Proof:Let A be an IFMαGCS in X.Let A⊆U and U be an intuitioistic fuzzy multi open set in (X,τ).By hypothesis,A∪cl(int(cl(A))⊆U. Therefore cl(int(cl(A))⊆U.

Therefore cl(int(A))⊆cl(int(cl(A))⊆U.Therefore cl(int(A))⊆U

Hence A is an IFMGPCS in X.

Example 3.12: Let X= {a,b} and let τ={ 0~ ,T , 1~} be an IFMT on X where p=2, Then

T=< x,(0.9,0.4),(0.3,0.8) , (0.1,0.6),(0.2,0.2)> and

A=< x,(0.8,0.3),(0.2,0.7) , (0.2,0.6),(0.3,0.2)> is an IFMGPCS in X but not an IFMαGCS in X since αcl(A)=1 ⊄ T.

Remark 3.13:IFMSCS and IFMGPCS are independent to each other which can be seen from the following Example**.**

Example 3.14: Let X ={a,b} and let τ = {0~ ,T , 1~} be an IFMT on X where p=2, Then

T=< x,(0.2,0.3),(0.4,0.2) , (0.5,0.4),(0.6,0.3)> and

A= < x,(0.2,0.3),(0.4,0.2) , (0.5,0.4),(0.6,0.3)>is an IFMGPCS in X but not an IFMSCS in X.

Example 3.15: Let X = {a,b} and let τ = {0~ ,T , 1~ } be an IFMT on X where p=2, Then

T=< x,(0.2,0.2),(0.3,0.4) , (0.6,0.6),(0.5,0.4)> and

A=< x,(0.3,0.2),(0.4,0.4) , (0.5,0.6),(0.5,0.4)> is an IFMSCS in X but not an IFMGPCS in X.

Remark 3.16: The Union of any two IFMGPCS need not be an IFMGPCS in general as seen from the following Example.

Example 3.17: Let X = {a,b} and let τ = {0~ ,T , 1~} be an IFMT on X where p=2,Then

T=< x,(0.2,0.3),(0.4,0.5) , (0.4,0.6),(0.4,0.2)> and

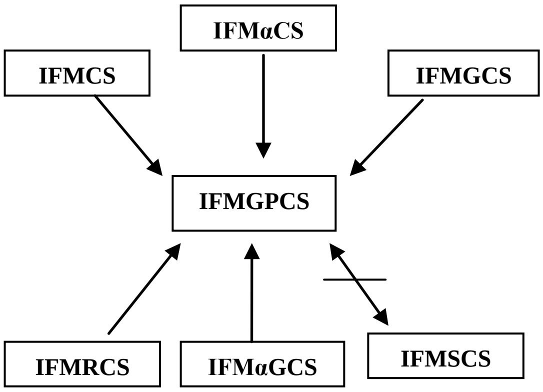
A= < x,(0.1,0.2),(0.3,0.4) , (0.5,0.6),(0.4,0.2)> and

B=< x,(0.1,0.2),(0.2,0.3) , (0.4,0.6),(0.5,0.2)> are IFMGPCS but A∪B is not an IFMGPCS in X.

The following figure represents the relation between intuitionistic fuzzy multi weakly generalized closed set and other existing intuitionistic fuzzy multi closed sets.

In this diagram "A ⟶ B means A implies B and

A ⟷ B means A and B are independent to each other.



4. INTUITIONISTIC FUZZY MULTI GENERALIZED PRE-OPEN SET

In this section we introduce Intuitionistic fuzzy multi weakly generalized open set and have studied some of its properties.

Definition 4.1: An IFMS A in an IFMTS (X,τ) is said to be an Intuitionistic fuzzy multi generalized pre-open set (IFMGPOS) in (X,τ) if the complement A^c is an IFMGPCS in X.

Example 4.2: Let X={a,b} and let τ={0~ ,T , 1~} be an IFMT on X where p=2,

Then T=< x,(0.5,0.6),(0.5,0.4) , (0.1,0.3),(0.3,0.4)> and

A=< x,(0.2,0.3),(0.3,0.4) , (0.4,0.6),(0.5,0.3)> is an IFMGPOS in X.

Theorem 4.3: For any IFMTS(X,τ),We have the following

i)Every IFMOS is an IFMGPOS

i)Every IFMSOS is an IFMGPOS

iii) Every IFMαOS is an IFMGPOS

iv) Every IFMROS is an IFMGPOS

Proof: Straight forward.

The Converse of the above statement need not be true in general which can be seen from the following Examples

Example 4.4: Let X={a,b} and let τ={0~ ,T , 1~} be an IFMT on X where p=2,Then

T=< x,(0.2,0.4),(0.3,0.4) , (0.3,0.3),(0.5,0.6)> and

A=< x,(0.4,0.3),(0.6,0.7) , (0.2,0.3),(0.2,0.3)> is an IFMGPOS in (X,τ) but not an IFMOS in X.

Example 4.5: Let X={a,b} and let τ={0~ ,T , 1~} be an IFMT on X where p=2,Then

T=< x,(0.2,0.3),(0.3,0.4) , (0.5,0.3),(0.2,0.4)> and

A=< x,(0.6,0.3),(0.4,0.5) , (0.2,0.2),(0.3,0.4)> is an IFMGPOS in (X.τ) but not an IFMSOS in X.

Example 4.6: Let X={a,b} and let τ={$0_\sim$,T , $1_\sim$} be an IFMT on X where p=2,Then

T=< x,(0.3,0.4),(0.3,0.3) , (0.6,0.5),(0.4,0.3)> and

A=< x,(0.6,0.5),(0.4,0.4) , (0.3,0.4),(0.2,0.3)> is an IFMGPOS in (X.τ) but not an IFMαOS in X.

Example 4.7: Let X={a,b} and let τ={$0_\sim$,T , $1_\sim$} be an IFMT on X where p=2,Then

T=< x,(0.3,0.4),(0.5,0.6) , (0.3,0.4),(0.3,0.2)> and

A=< x,(0.6,0.5),(0.4,0.5) , (0.2,0.3),(0.2,0.4)> is an IFMGPOS in (X.τ) but not an IFMPOS in X.

Theorem 4.8: Let(X, τ) be an IFMTS.Then for every A∈IFMGMO(X) and for every B∈IFS(X),pint(A)⊆B⊆A implies B∈IFMGPO(X)

Proof: By hypothesis $A^c \subseteq B^c \subseteq (pint(A))^c$.Let $B^c \subseteq$U and U and U be an IFMOS.Since $A^c \subseteq B^c$, $A^c \subseteq$U.But A^c is an IFMGPCS,pcl(A^c)⊆U.Also $B^c \subseteq (pint(A))^c$ = pcl(A^c).

Therefore pcl(B^c)⊆pcl(A^c)⊆U. Hence B^c is an IFMGPCS.Which implies B is an IFMGPOS of X

Theorem 4.9: An IFMS A of an IFMTS(X,τ) is an IFMGPOS if and only if F⊆int(cl(A)) whenever F is an IFMCS and F⊆A.

Proof:**Necessary:** Suppose A is an IFGPOS in X.Let F be an IFMCS and F⊆A. Then F^c is an IFOS in X such that $A^c \subseteq F^c$

.Since A^c is an IFMGPCS, cl(int(A^c)) ⊆ F^c. Hence

$(int(cl(A)))^c \subseteq F^C$. This implies F ⊆int(cl(A)).

Sufficient: Let Abe an IFMS of X and F ⊆ (int(cl(A)) whenever F is an IFMCS and F ⊆A.Then $A^c \subseteq F^c$ and F^c is an IFMOS.By hypothesis, $(int(cl(A)))^c \subseteq F^c$. Hence cl(int($A^c$))⊆$F^c$.Hence A is an IFMWGOS of X.

Theorem 4.10: For an IFS A, A is an IFMOS and an IFMGPCS in X if and only if A is an IFROS inX.

Proof:**Necessary:**Let A be an IFMOS and an IFMGPCS inX. Then pcl(A)⊆A. This implies cl(int(A))⊆A. Since A is an IFMOS,it is an IFMPOS.Hence A⊆int(cl(A)).Therefore A=int(cl(A)).Hence A is an IFMROS in X.

Sufficient: Let A be an IFMROS in X.Therefore A=int(cl(A)).Let A⊆U and U is an IFMOS inX. This implies pcl(A)⊆A.Hence A is an IFMGPCS in X.

5. CONCLUSION

In this paper we have introduced a new class of Intuitionistic fuzzy multi closed set namely Intuitionistic fuzzy multi generalized pre-closed set and have studied the relationship between Intuitionistic fuzzy multi generalized pre-closed set and other existing Intuitionistic fuzzy multi closed sets.Also we have investigated some of the properties of Intuitionistic fuzzy multi generalized pre-closed set.The concept of multi intuitionism can be applied in information retrivel and flexiable querying and there is a scope for detailed analysis about this topic.

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