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To cite this article: R. Krishna Moorthy et al 2018 J. Phys.: Conf. Ser. 1000 012104

View the article online for updates and enhancements.
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Abstract. In this paper, we introduce a new class of sets namely α weakly generalized closed sets which is properly placed between class of intuitionistic α-closed sets and intuitionistic fuzzy weakly generalized closed sets.

1. Introduction
Fuzzy Probability theory is capable of representing only one of several distinct types of uncertainty. An important point and evolution of the modern concept of uncertainty was the publication of a seminar paper by Lofti A. Zadeh (1965). In his paper, Zadeh [19] introduced a theory whose objects - fuzzy sets - are sets with boundaries that are not precise. In 1986, Atanassov [1] introduced the concept of intuitionistic fuzzy sets as a natural generalization of standard fuzzy sets. The concept of Fuzzy topology was introduced by Chang [3] in 1968 and intuitionistic fuzzy topology by Coker [4] in 1997.

In this paper, we introduce one of the concepts namely α-weakly generalized closed sets which were introduced initially by Devi [5] in General Topology in 2004. We have studied some of the basic properties regarding it. For terms and notations used but left undefined we refer to [1, 4, 10, 11, 12, 14, 16, 18].

2. Preliminaries
Definition 2.1: [1] Let X be a nonempty fixed set. An intuitionistic fuzzy set (IFS in short) A in X is an object having the form A = { (x, μ_A(x), ν_A(x)) | x ∈ X } where the function μ_A : X → [0, 1] is called the membership function and μ_A(x) denote the degree to which x ∈ A and the function ν_A : X → [0, 1] is called the non-membership function and ν_A(x) denotes the degree to which x ∈ A and 0 ≤ μ_A(x) + ν_A(x) ≤ 1 for each x ∈ X.

Definition 2.2: [4] An intuitionistic fuzzy topology (IFT in short) on a nonempty set X is a family τ of IFSs in X satisfying the following axioms:

(i) 0, 1 ∈ τ,
(ii) G₁, G₂ ∈ τ for any G₁, G₂ ∈ τ,
(iii) \( Y_{G_i} \in \tau \) for any arbitrary family \( \{G_i \mid i \in J\} \subseteq \tau \).

In this case, the pair \((X, \tau)\) is called an intuitionistic fuzzy topological space (IFTS in short) and each IFS in \( \tau \) is known as an intuitionistic fuzzy open set (IFOS in short) in \( X \).

The complement \( A^c \) of an IFOS \( A \) in an IFTS \((X, \tau)\) is called an intuitionistic fuzzy closed set (IFCS in short) in \( X \).

**Definition 2.3:** An IFS \( A = \{ (x, \mu_A(x), \nu_A(x)) / x \in X \} \) in an IFTS \((X, \tau)\) is called an

- intuitionistic fuzzy semi closed set [6] (IFSCS) if \( \text{int}(\text{cl}(A)) \subseteq A \),
- intuitionistic fuzzy \( \alpha \)-closed set [6] (IF\( \alpha \)CS) if \( \text{cl}(\text{int}(\text{cl}(A))) \subseteq A \),
- intuitionistic fuzzy pre-closed set [6] (IFPCS) if \( \text{cl}(\text{int}(A)) \subseteq A \),
- intuitionistic fuzzy regular closed set [6] (IFRCS) if \( \text{cl}(\text{int}(A)) = A \),
- intuitionistic fuzzy generalized closed set [15] (IFGCS) if \( \text{cl}(A) \subseteq U \) whenever \( A \subseteq U \) and \( U \) is an IFOS,
- intuitionistic fuzzy generalized semi closed set [12] (IFGSCS) if \( \text{scl}(A) \subseteq U \) whenever \( A \subseteq U \) and \( U \) is an IFOS,
- intuitionistic fuzzy \( \alpha \) generalized closed set [10] (IF\( \alpha \)GCS) if \( \text{cl}(A) \subseteq U \), whenever \( A \subseteq U \) and \( U \) is an IFOS.

An IFS \( A \) is called intuitionistic fuzzy semi open set, intuitionistic fuzzy \( \alpha \)-open set, intuitionistic fuzzy pre-open set, intuitionistic fuzzy regular open set, intuitionistic fuzzy generalized open set, intuitionistic fuzzy generalized semi open set and intuitionistic fuzzy \( \alpha \) generalized open set (IFSOS, IF\( \alpha \)OS, IFPOS, IFROS, IFGOS, IFGSOS and IF\( \alpha \)GOS) if the complement of \( A^c \) is an IFSCS, IF\( \alpha \)CS, IFPCS, IFRCS, IFGCS, IFGSCS and IF\( \alpha \)GCS respectively.

### 3. \( \alpha \) weakly generalized closed sets in intuitionistic fuzzy topological spaces

In this section, we introduce a new class of generalized closed sets called intuitionistic fuzzy \( \alpha \) weakly generalized closed sets and study some of their properties.

**Definition 3.1:** An IFS \( A = \{ (x, \mu_A(x), \nu_A(x)) / x \in X \} \) in an IFTS \((X, \tau)\) is said to be an intuitionistic fuzzy \( \alpha \)-weakly generalized closed set (IF\( \alpha \)WGCS in short) if \( \text{cl}(\text{int}(A)) \subseteq U \) whenever \( A \subseteq U \) and \( U \) is an IF\( \alpha \)OS in \((X, \tau)\).

The family of all IF\( \alpha \)WGCSs of an IFTS \((X, \tau)\) is denoted by IF\( \alpha \)WGC(X).

**Example 3.2:** Let \( X = \{a, b\} \) and let \( \tau = \{0_{\tau}, T, 1_{\tau}\} \) be an IFT on \( X \) where \( T = \left[ \begin{array}{cc} a & b \\ 0.1 & 0.2 \end{array} \right] \left[ \begin{array}{cc} a & b \\ 0.9 & 0.8 \end{array} \right] \). Here \( \mu_T(a) = 0.1, \mu_T(b) = 0.2, \nu_T(a) = 0.9 \) and \( \nu_T(b) = 0.8 \). Consider the IFS \( A = \left[ \begin{array}{cc} a & b \\ 0.1 & 0.1 \end{array} \right] \left[ \begin{array}{cc} a & b \\ 0.9 & 0.8 \end{array} \right] \). Clearly if \( A \subseteq 1_{\tau} \) then \( \text{cl}(\text{int}(A)) \subseteq 1_{\tau} \). Now let us consider the IF\( \alpha \)OS \( T \) in \( X \). Clearly the IFS \( A \subseteq T \). Now \( \text{cl}(\text{int}(A)) \subseteq 1_{\tau} \). Hence \( \text{cl}(\text{int}(A)) \subseteq U \) whenever \( A \subseteq U \) and \( U \) is an IF\( \alpha \)OS in \( X \). Therefore the IFS \( A = \left[ \begin{array}{cc} a & b \\ 0.1 & 0.1 \end{array} \right] \left[ \begin{array}{cc} a & b \\ 0.9 & 0.8 \end{array} \right] \) is an IF\( \alpha \)WGCS in \( X \).

**Example 3.3:** Let \( X = \{a, b\} \) and let \( \tau = \{0_{\tau}, T, 1_{\tau}\} \) be an IFT on \( X \) where \( T = \left[ \begin{array}{cc} a & b \\ 0.4 & 0.5 \end{array} \right] \left[ \begin{array}{cc} a & b \\ 0.6 & 0.7 \end{array} \right] \). Consider the IFS \( A = \left[ \begin{array}{cc} a & b \\ 0.4 & 0.5 \end{array} \right] \left[ \begin{array}{cc} a & b \\ 0.6 & 0.7 \end{array} \right] \). Now let us
consider the IF\(\alpha\)OS \(T\) in \(X\). Clearly the IFS \(A \subseteq T\). Now \(\text{cl}(\text{int}(A)) = T^c \not\subseteq T\). Therefore the IFS \(A = \left\{ \begin{array}{cc} a & b \\ 0.4 & 0.5 \end{array} \right\} \left\{ \begin{array}{cc} a & b \\ 0.6 & 0.7 \end{array} \right\}\) is not an IF\(\alpha\)WGCS in \(X\).

**Theorem 3.4:** Every IFCS in an IFTS \((X, \tau)\) is an IF\(\alpha\)WGCS but not conversely.

**Proof:** Assume that \(A\) is an IFCS in \(X\). Let us consider the IFS \(A \subseteq U\) and \(U\) be an IF\(\alpha\)OS in \(X\). Since \(\text{cl}(\text{int}(A)) \subseteq \text{cl}(A)\) and \(A\) is an IFCS in \(X\), \(\text{cl}(\text{int}(A)) \subseteq \text{cl}(A) = A \subseteq U\). Therefore \(\text{cl}(\text{int}(A)) \subseteq U\) whenever \(A \subseteq U\) and \(U\) is an IF\(\alpha\)OS in \(X\). Hence \(A\) is an IF\(\alpha\)WGCS in \(X\).

**Example 3.5:** Let \(X = \{a, b\}\) and let \(\tau = \{0, T, 1\}\) be an IFT on \(X\) where 
\[
T = \begin{pmatrix} 0.3 & 0.5 \\ 0.7 & 0.5 \end{pmatrix} \begin{pmatrix} a & b \\ 0.2 & 0.2 \end{pmatrix} \begin{pmatrix} a & b \\ 0.8 & 0.7 \end{pmatrix}.
\]
Consider the IFS \(A = \left\{ \begin{array}{cc} a & b \\ 0.2 & 0.2 \end{array} \right\} \left\{ \begin{array}{cc} a & b \\ 0.8 & 0.7 \end{array} \right\}\). Clearly \(A \subseteq T\) and \(\text{cl}(\text{int}(A)) = 0. \not\subseteq T\). Hence \(A\) is an IF\(\alpha\)WGCS in \(X\) but not an IFS in \(X\), since \(\text{cl}(A) = \left\{ \begin{array}{cc} a & b \\ 0.7 & 0.5 \end{array} \right\} \left\{ \begin{array}{cc} a & b \\ 0.3 & 0.5 \end{array} \right\}\) is \(T^c \neq A\).

**Corollary 3.6:** Every IFRCS in an IFTS \((X, \tau)\) is an IF\(\alpha\)WGCS but not conversely.

**Proof:** Let \(A\) be an IFRCS in \(X\). In [6], it has been proved that every IFRCS is an IFS in \(X\). Therefore \(A\) is an IFS in \(X\). Hence by Theorem 3.4, \(A\) is an IF\(\alpha\)WGCS in \(X\).

**Example 3.7:** Let \(X = \{a, b\}\) and let \(\tau = \{0, T, 1\}\) be an IFT on \(X\) where 
\[
T = \begin{pmatrix} 0.3 & 0.5 \\ 0.7 & 0.5 \end{pmatrix} \begin{pmatrix} a & b \\ 0.2 & 0.2 \end{pmatrix} \begin{pmatrix} a & b \\ 0.8 & 0.8 \end{pmatrix}.
\]
Then the IFS \(A = \left\{ \begin{array}{cc} a & b \\ 0.1 & 0.2 \end{array} \right\} \left\{ \begin{array}{cc} a & b \\ 0.9 & 0.8 \end{array} \right\}\) is an IF\(\alpha\)WGCS in \(X\) but not an IFRCS in \(X\), since \(\text{cl}(\text{int}(A)) = 0. \neq A\).

**Theorem 3.8:** Every IFGCS in an IFTS \((X, \tau)\) is an IF\(\alpha\)WGCS but not conversely.

**Proof:** Assume that \(A\) is an IFGCS in \(X\). Let us consider the IFS \(A \subseteq U\) and \(U\) be an IF\(\alpha\)OS in \(X\). By hypothesis, \(\text{cl}(\text{int}(A)) \subseteq \text{cl}(A) \subseteq U\). Clearly \(\text{cl}(\text{int}(A)) \subseteq \text{cl}(A) \subseteq U\). Hence \(A\) is an IF\(\alpha\)WGCS in \(X\).

**Example 3.9:** Let \(X = \{a, b\}\) and let \(\tau = \{0, T, 1\}\) be an IFT on \(X\) where 
\[
T = \begin{pmatrix} 0.3 & 0.5 \\ 0.7 & 0.5 \end{pmatrix} \begin{pmatrix} a & b \\ 0.2 & 0.1 \end{pmatrix} \begin{pmatrix} a & b \\ 0.8 & 0.9 \end{pmatrix}.
\]
Then the IFS \(A = \left\{ \begin{array}{cc} a & b \\ 0.8 & 0.9 \end{array} \right\} \left\{ \begin{array}{cc} a & b \\ 0.2 & 0.1 \end{array} \right\}\) is an IF\(\alpha\)WGCS in \(X\) but not an IFGCS in \(X\), since \(A \subseteq T\) but \(\text{cl}(A) = \left\{ \begin{array}{cc} a & b \\ 0.8 & 0.9 \end{array} \right\} \left\{ \begin{array}{cc} a & b \\ 0.2 & 0.1 \end{array} \right\}\) is \(T^c \not\subseteq T\).

**Theorem 3.10:** Every IFPCS in an IFTS \((X, \tau)\) is an IF\(\alpha\)WGCS but not conversely.

**Proof:** Assume that \(A\) is an IFPCS in \(X\). Let us consider the IFS \(A \subseteq U\) and \(U\) be an IF\(\alpha\)OS in \(X\). By hypothesis, \(\text{cl}(\text{int}(A)) \subseteq A\). Hence \(A\) is an IF\(\alpha\)WGCS in \(X\).

**Example 3.11:** Let \(X = \{a, b\}\) and let \(\tau = \{0, T, 1\}\) be an IFT on \(X\) where 
\[
T = \begin{pmatrix} 0.3 & 0.5 \\ 0.7 & 0.5 \end{pmatrix} \begin{pmatrix} a & b \\ 0.4 & 0.6 \end{pmatrix} \begin{pmatrix} a & b \\ 0.5 & 0.4 \end{pmatrix}.
\]
Then the IFS \(A = \left\{ \begin{array}{cc} a & b \\ 0.8 & 0.4 \end{array} \right\} \left\{ \begin{array}{cc} a & b \\ 0.2 & 0.6 \end{array} \right\}\) is an IFWGCS in \(X\) but not an IFPCS in \(X\), since \(\text{cl}(\text{int}(A)) = \left\{ \begin{array}{cc} a & b \\ 0.5 & 0.4 \end{array} \right\} \left\{ \begin{array}{cc} a & b \\ 0.5 & 0.4 \end{array} \right\}\) is \(T^c \not\subseteq A\).
Theorem 3.12: Every $\text{IF}\, \alpha\, \text{GCS}$ in an IFTS $(X, \tau)$ is an $\text{IF}\, \alpha\, \text{WGCS}$ but not conversely.

Proof: Assume that $A$ is an $\text{IF}\, \alpha\, \text{GCS}$ in $X$. Let us consider the IFS $A \subseteq U$ and $U$ be an $\text{IF}\, \alpha\, \text{OS}$ in $X$. By hypothesis, $\alpha\, \text{cl}(A) = A \cup \text{cl}(\text{int}(\text{cl}(A))) \subseteq U$. This implies $\text{cl}(\text{int}(\text{cl}(A))) \subseteq U$. Clearly $\text{cl}(\text{int}(A)) \subseteq \text{cl}(\text{int}(\text{cl}(A))) \subseteq U$. Hence $A$ is an $\alpha\, \text{WGCS}$ in $X$.

Example 3.13: Let $X = \{a, b\}$ and let $\tau = \{0., T, 1.\}$ be an IFT on $X$ where $T = \left\langle x, \begin{pmatrix} a & b \\ 0.5 & 0.7 \\ 0.5 & 0.3 \end{pmatrix} \right\rangle$. Then the IFS $A = \left\langle x, \begin{pmatrix} a & b \\ 0.3 & 0.5 \\ 0.6 & 0.5 \end{pmatrix} \right\rangle$ is an $\text{IF}\, \alpha\, \text{WGCS}$ in $X$ but not an $\text{IF}\, \alpha\, \text{GCS}$ in $X$, since $\alpha\, \text{cl}(A) = 1. \not\subseteq T$.

Corollary 3.14: Every $\text{IF}\, \alpha\, \text{CS}$ in an IFTS $(X, \tau)$ is an $\text{IF}\, \alpha\, \text{WGCS}$ but not conversely.

Proof: Assume that $A$ is an $\text{IF}\, \alpha\, \text{CS}$ in $X$. In [11], it has been proved that every $\text{IF}\, \alpha\, \text{CS}$ is an $\text{IF}\, \alpha\, \text{GCS}$ in $X$. Therefore $A$ is an $\text{IF}\, \alpha\, \text{GCS}$ in $X$. Hence by Theorem 3.12, $A$ is an $\alpha\, \text{WGCS}$ in $X$.

Example 3.15: Let $X = \{a, b\}$ and let $\tau = \{0., T, 1.\}$ be an IFT on $X$ where $T = \left\langle x, \begin{pmatrix} a & b \\ 0.5 & 0.7 \\ 0.5 & 0.3 \end{pmatrix} \right\rangle$. Then the IFS $A = \left\langle x, \begin{pmatrix} a & b \\ 0.6 & 0.5 \end{pmatrix} \right\rangle$ is an $\text{IF}\, \alpha\, \text{WGCS}$ in $X$ but not an $\text{IF}\, \alpha\, \text{CS}$ in $X$, since $\text{cl}(\text{int}(\text{cl}(A))) = \left\langle x, \begin{pmatrix} a & b \\ 0.3 & 0.5 \end{pmatrix} \right\rangle = T^c \not\subseteq A$.

Remark 3.16: $\text{IF}\, \alpha\, \text{WG}$ closedness is independent of IFS closedness in general as seen from the following examples.

Example 3.17: Let $X = \{a, b\}$ and let $\tau = \{0., T, 1.\}$ be an IFT on $X$ where $T = \left\langle x, \begin{pmatrix} a & b \\ 0.3 & 0.5 \end{pmatrix} \right\rangle$. Then the IFS $A = T$ is an $\text{IF}\, \alpha\, \text{CS}$ in $X$ but not an $\alpha\, \text{WGCS}$ in $X$, since $A \subseteq T$ but $\text{cl}(\text{int}(A)) = T^c$.

Example 3.18: Let $X = \{a, b\}$ and let $\tau = \{0., T, 1.\}$ be an IFT on $X$ where $T = \left\langle x, \begin{pmatrix} a & b \\ 0.7 & 0.7 \end{pmatrix} \right\rangle$. Then the IFS $A = \left\langle x, \begin{pmatrix} a & b \\ 0.3 & 0.3 \end{pmatrix} \right\rangle$ is an $\text{IF}\, \alpha\, \text{WGCS}$ in $X$ but not an $\text{IF}\, \alpha\, \text{CS}$ in $X$, since $\text{int}(\text{cl}(A)) = T^c$.

Remark 3.19: $\text{IF}\, \alpha\, \text{WG}$ closedness is independent of IFGS closedness in general as seen from the following examples.

Example 3.20: Let $X = \{a, b\}$ and let $\tau = \{0., T, 1.\}$ be an IFT on $X$ where $T = \left\langle x, \begin{pmatrix} a & b \\ 0.3 & 0.3 \end{pmatrix} \right\rangle$. Then the IFS $A = T$ is an $\text{IF}\, \alpha\, \text{CS}$ in $X$ but not an $\alpha\, \text{WGCS}$ in $X$, since $A \subseteq T$ but $\text{cl}(\text{int}(A)) = T^c$.
Example 3.21: Let $X = \{a, b\}$ and let $\tau = \{0, T, 1\}$ be an IFT on $X$ where $T = \left\langle x, \left(\begin{array}{l} a \\ 0.7 \cdot 0.8 \end{array}\right), \left(\begin{array}{l} a \\ 0.2 \cdot 0.1 \end{array}\right)\right\rangle$. Then the IFS $A = \left\langle x, \left(\begin{array}{l} a \\ 0.6 \cdot 0.7 \end{array}\right), \left(\begin{array}{l} a \\ 0.4 \cdot 0.3 \end{array}\right)\right\rangle$ is an $\alpha$-WGCS in $X$ but not an $\alpha$-GCS in $X$, since $\text{cl}(A) = A \cup \text{int}(\text{cl}(A)) = 1 \not\subseteq T$.

Theorem 3.22: If $A$ is an $\alpha$-WGCS in an IFTS $(X, \tau)$ and $A \subseteq B \subseteq \text{cl}(\text{int}(A))$, then $B$ is an $\alpha$-WGCS in $X$.

Proof: Let $U$ be an $\alpha$-OS in $X$ such that $B \subseteq U$. Since $A \subseteq B$, we have $A \subseteq U$. But $A$ is an $\alpha$-WGCS, so $\text{cl}(\text{int}(A)) \subseteq U$. By hypothesis, $B \subseteq \text{cl}(\text{int}(A))$. Therefore $\text{cl}(\text{int}(B)) \subseteq \text{cl}(\text{int}(A))$. This implies $\text{cl}(\text{int}(B)) \subseteq U$. Hence $B$ is an $\alpha$-WGCS in $X$.

Remark 3.23: The union of two $\alpha$-WGCSs need not be an $\alpha$-WGCS in general as seen from the following example.

Example 3.24: Let $X = \{a, b\}$ and let $\tau = \{0, T, 1\}$ be an IFT on $X$ where $T = \left\langle x, \left(\begin{array}{l} a \\ 0.6 \cdot 0.8 \end{array}\right), \left(\begin{array}{l} a \\ 0.4 \cdot 0.2 \end{array}\right)\right\rangle$. Then the IFSs $A = \left\langle x, \left(\begin{array}{l} a \\ 0.1 \cdot 0.8 \end{array}\right), \left(\begin{array}{l} a \\ 0.9 \cdot 0.2 \end{array}\right)\right\rangle$ and $B = \left\langle x, \left(\begin{array}{l} a \\ 0.6 \cdot 0.7 \end{array}\right), \left(\begin{array}{l} a \\ 0.4 \cdot 0.3 \end{array}\right)\right\rangle$ are $\alpha$-WGCS in $X$. But the IFS $A \cup B = \left\langle x, \left(\begin{array}{l} a \\ 0.6 \cdot 0.8 \end{array}\right), \left(\begin{array}{l} a \\ 0.4 \cdot 0.2 \end{array}\right)\right\rangle$ is not an $\alpha$-WGCS in $X$, since $\text{cl}(\text{int}(A \cup B)) = 1 \not\subseteq T$ even though $A \cup B \subseteq T$ and $T$ is an $\alpha$-OS in $X$.

Remark 3.25: The intersection of two $\alpha$-WGCSs need not be an $\alpha$-WGCS in general as seen from the following example.

Example 3.26: Let $X = \{a, b\}$ and let $\tau = \{0, T, 1\}$ be an IFT on $X$ where $T = \left\langle x, \left(\begin{array}{l} a \\ 0.5 \cdot 0.7 \end{array}\right), \left(\begin{array}{l} a \\ 0.5 \cdot 0.3 \end{array}\right)\right\rangle$. Then the IFSs $A = \left\langle x, \left(\begin{array}{l} a \\ 0.5 \cdot 0.8 \end{array}\right), \left(\begin{array}{l} a \\ 0.5 \cdot 0.2 \end{array}\right)\right\rangle$ and $B = \left\langle x, \left(\begin{array}{l} a \\ 0.6 \cdot 0.7 \end{array}\right), \left(\begin{array}{l} a \\ 0.4 \cdot 0.3 \end{array}\right)\right\rangle$ are $\alpha$-WGCS in $X$. But the IFS $A \cap B = \left\langle x, \left(\begin{array}{l} a \\ 0.5 \cdot 0.7 \end{array}\right), \left(\begin{array}{l} a \\ 0.5 \cdot 0.3 \end{array}\right)\right\rangle$ is not an $\alpha$-WGCS in $X$, since $\text{cl}(\text{int}(A \cap B)) = 1 \not\subseteq T$ even though $A \cap B \subseteq T$ and $T$ is an $\alpha$-OS in $X$. 


**Remark 3.27:** We have the following implication diagram

![Diagram](image)

**Fig.1** Relation between intuitionistic fuzzy $\alpha$ weakly generalized closed set and other existing intuitionistic fuzzy closed sets

In this diagram by “A $\rightarrow$ B” we mean A implies B but not conversely and “A $\leftrightarrow$ B” means A and B are independent of each other.

None of them is reversible.

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