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Intuitionistic fuzzy contra weakly generalized irresolute mappings

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Abstract: The purpose of this paper is to introduce and study the concepts of intuitionistic fuzzy contra weakly generalized irresolute mappings and intuitionistic fuzzy perfectly contra weakly generalized irresolute mappings in intuitionistic fuzzy topological space. Some of their properties are explored.
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1 Introduction

Fuzzy set (FS) as proposed by Zadeh [16] in 1965 is a framework to encounter uncertainty, vagueness and partial truth and it represents a degree of membership for each member of the universe of discourse to a subset of it. After the introduction of fuzzy topology by Chang [2] in 1968, there have been several generalizations of notions of fuzzy sets and fuzzy topology. By adding the degree of non-membership to FS, Atanassov [1] proposed intuitionistic fuzzy set (IFS) in 1986 which appeals more accurate to uncertainty quantification and provides the opportunity to precisely model the problem, based on the existing knowledge and observations. In 1997, Coker [3] introduced the concept of intuitionistic fuzzy topological space. This paper aspires to overtly enunciate the notion of intuitionistic fuzzy contra weakly generalized irresolute mappings and intuitionistic fuzzy perfectly contra weakly generalized irresolute mappings in intuitionistic fuzzy topological space and study some of their properties. We provide some characterizations of intuitionistic fuzzy contra weakly generalized irresolute mappings and establish the relationships with other classes of early defined forms of intuitionistic mappings. For terms and notations used but left undefined we refer to [1, 3, 5, 6, 13–15].

2 Preliminaries

Definition 2.1. [7] An IFS $A = \{\langle x, \mu_A(x), \nu_A(x)\rangle \mid x \in X\}$ in an IFTS (X, τ) is said to be an *intuitionistic fuzzy weakly generalized closed set* (IFWGCS in short) if $\mathrm{cl}(\mathrm{int}(A)) \subseteq U$ whenever $A \subseteq U$ and U is an IFOS in X. The family of all IFWGCSs of an IFTS (X, τ) is denoted by IFWGC(X).

Definition 2.2. [7] An IFS A is said to be an *intuitionistic fuzzy weakly generalized open set* (IFWGOS in short) in (X, τ) if the complement A^c is an IFWGCS in (X, τ). The family of all IFWGOSs of an IFTS (X, τ) is denoted by IFWGO(X).

Result 2.3. [7] Every IFCS, IFαCS, IFGCS, IFRCS, IFPCS, IFαGCS is an IFWGCS but the converses need not be true in general.

Definition 2.4. [8] Let (X, τ) be an IFTS and $A = \langle x, \mu_A(x), \nu_A(x)\rangle$ be an IFS in X. Then the *intuitionistic fuzzy weakly generalized interior* and *intuitionistic fuzzy weakly generalized closure* are defined by

$$\mathrm{wgint}(A) = \cup \{ G \mid G \text{ is an IFWGOS in } X \text{ and } G \subseteq A \},$$
$$\mathrm{wgcl}(A) = \cap \{ K \mid K \text{ is an IFWGCS in } X \text{ and } A \subseteq K \}.$$

Definition 2.5. Let f be a mapping from an IFTS (X, τ) into an IFTS (Y, σ). Then f is said to be

(i) *intuitionistic fuzzy contra continuous* [4] if $f^{-1}(B)$ is an IFCS in X for every IFOS B in Y,

(ii) *intuitionistic fuzzy contra weakly generalized continuous* [11] if $f^{-1}(B)$ is an IFWGOS in X for every IFCS B in Y,

(iii) *intuitionistic fuzzy perfectly weakly generalized continuous* [10] if $f^{-1}(B)$ is an intuit-tionistic fuzzy clopen set in X for every IFWGOS B in Y,

(iv) *intuitionistic fuzzy totally weakly generalized continuous* [12] if $f^{-1}(B)$ is an intuitionistic fuzzy weakly generalized clopen set in X for every IFOS B in Y,

(v) *intuitionistic fuzzy weakly generalized continuous* [9] (IFWG continuous in short) if $f^{-1}(B)$ is an IFWGCS in X for every IFCS B in Y,

(vi) *intuitionistic fuzzy weakly generalized irresolute* [8] (IFWG irresolute in short) if $f^{-1}(B)$ is an IFWGCS in X for every IFWGCS B in Y.

Definition 2.6. [7] An IFTS (X, τ) is said to be an *intuitionistic fuzzy* $_{wg}T_{1/2}$ *space* ($\mathrm{IF}_{wg}\mathrm{T}_{1/2}$ space in short) if every IFWGCS in X is an IFCS in X.

Definition 2.7. [7] An IFTS (X, τ) is said to be an *intuitionistic fuzzy* $_{wg}T_p$ *space* ($\mathrm{IF}_{wg}\mathrm{T}_p$ space in short) if every IFWGCS in X is an IFPCS in X.

3 Intuitionistic fuzzy contra weakly generalized irresolute mappings

In this section, we introduce intuitionistic fuzzy contra weakly generalized irresolute mappings and intuitionistic fuzzy perfectly contra weakly generalized irresolute mappings in intuitionistic fuzzy topological space and study some of their properties.

Definition 3.1. A mapping $f : (X, \tau) \to (Y, \sigma)$ is called an *intuitionistic fuzzy contra weakly generalized irresolute mapping* if $f^{-1}(B)$ is an IFWGCS in (X, τ) for every IFWGOS B in (Y, σ).

Theorem 3.2. If $f : (X, \tau) \to (Y, \sigma)$ is an intuitionistic fuzzy contra weakly generalized irresolute mapping then f is an intuitionistic fuzzy contra weakly generalized continuous mapping but not conversely.

Proof. Let f be an intuitionistic fuzzy contra weakly generalized irresolute mapping. Let A be an IFCS in Y. Since every IFCS is an IFWGCS, A is an IFWGCS in Y. By hypothesis, $f^{-1}(A)$ is an IFWGOS in X. Hence f is an intuitionistic fuzzy contra weakly generalized continuous mapping. ☐

Example 3.3. Let $X = \{a, b\}$, $Y = \{u, v\}$ and $T_1 = \langle x, (0.2, 0.4), (0.7, 0.4)\rangle$, $T_2 = \langle y, (0.6, 0.7), (0.4, 0.2)\rangle$. Then $\tau = \{\tilde{0}, T_1, \tilde{1}\}$ and $\sigma = \{\tilde{0}, T_2, \tilde{1}\}$ are IFTs on X and Y respectively. Define a mapping $f : (X, \tau) \to (Y, \sigma)$ by $f(a) = u$ and $f(b) = v$. Then f is an intuitionistic fuzzy contra weakly generalized continuous mapping. But f is not an intuitionistic fuzzy contra weakly generalized irresolute mapping, since the IFS $B = \langle y, (0.2, 0.2), (0.7, 0.5)\rangle$ is an IFWGOS in Y but $f^{-1}(B) = \langle x, (0.2, 0.2), (0.7, 0.5)\rangle$ is not an IFWGCS in X.

Theorem 3.4. Let $f : (X, \tau) \to (Y, \sigma)$ be an intuitionistic fuzzy contra weakly generalized continuous mapping and (Y, σ) an $IF_{wg}T_{1/2}$ space. Then f is an intuitionistic fuzzy contra weakly generalized irresolute mapping.

Proof. Let B be an IFWGCS in Y. Since (Y, σ) is an $IF_{wg}T_{1/2}$ space, B is an IFCS in Y. By hypothesis, $f^{-1}(B)$ is an IFWGOS in Y. Hence f is an intuitionistic fuzzy contra weakly generalized irresolute mapping. ☐

Theorem 3.5. If $f : (X, \tau) \to (Y, \sigma)$ is an intuitionistic fuzzy perfectly weakly generalized continuous mapping then f is an intuitionistic fuzzy contra weakly generalized irresolute mapping.

Proof. Let f be an intuitionistic fuzzy perfectly weakly generalized continuous mapping. Let A be an IFWGOS in Y. By hypothesis, $f^{-1}(A)$ is an intuitionistic fuzzy clopen set in X. Since every IFCS is an IFWGCS, $f^{-1}(A)$ is an IFWGCS in X. Hence f is an intuitionistic fuzzy contra weakly generalized irresolute mapping. ☐

Theorem 3.6. If $f : (X, \tau) \to (Y, \sigma)$ is an intuitionistic fuzzy totally weakly generalized continuous mapping and (Y, σ) an $IF_{wg}T_{1/2}$ space then f is an intuitionistic fuzzy contra weakly generalized irresolute mapping.

Proof. Let f be an intuitionistic fuzzy totally weakly generalized continuous mapping. Let A be an IFWGOS in Y. Since (Y, σ) is an $IF_{wg}T_{1/2}$ space, A is an IFOS in Y. By hypothesis, $f^{-1}(A)$ is intuitionistic fuzzy weakly generalized clopen set in X. Hence f is an intuitionistic fuzzy contra weakly generalized irresolute mapping. □

Theorem 3.7. Let $f : (X, \tau) \to (Y, \sigma)$ be a mapping from an IFTS (X, τ) into an IFTS (Y, σ). Then the following statements are equivalent.

(i) f is an intuitionistic fuzzy contra weakly generalized irresolute mapping,

(ii) $f^{-1}(B)$ is an IFWGOS in X for every IFWGCS B in Y.

Proof.

(i) ⇒ (ii): Let B be an IFWGCS in Y. Then B^c is an IFWGOS in Y. By hypothesis, $f^{-1}(B^c) = = (f^{-1}(B))^c$ is an IFWGCS in X. Hence $f^{-1}(B)$ is an IFWGOS in X.

(ii) ⇒ (i): Let B be an IFWGOS in Y. Then B^c is an IFWGCS in Y. By (ii), $f^{-1}(B^c) = (f^{-1}(B))^c$ is an IFWGOS in X. Hence $f^{-1}(B)$ is an IFWGCS in X. Therefore f is an intuitionistic fuzzy contra weakly generalized irresolute mapping. □

Theorem 3.8. Let $f : (X, \tau) \to (Y, \sigma)$ be an intuitionistic fuzzy contra weakly generalized irresolute mapping and (X, τ) an $IF_{wg}T_{1/2}$ space. Then f is an intuitionistic fuzzy contra continuous mapping.

Proof. Let B be an IFCS in Y. Then B is an IFWGCS in Y. By hypothesis, $f^{-1}(B)$ is an IFWGOS in X. Since (X, τ) is an $IF_{wg}T_{1/2}$ space, $f^{-1}(B)$ is an IFOS in X. Hence f is an intuitionistic fuzzy contra continuous mapping. □

Theorem 3.9. Let $f : (X, \tau) \to (Y, \sigma)$ be a bijective mapping from an IFTS (X, τ) into an IFTS (Y, σ). Suppose that one of the following properties hold:

(i) $f(\text{wgcl}(A)) \subseteq \text{wgint}(f(A))$ for each IFS A in X,

(ii) $\text{wgcl}(f^{-1}(B)) \subseteq f^{-1}(\text{wgint}(B))$ for each IFS B in Y,

(iii) $f^{-1}(\text{wgcl}(B)) \subseteq \text{wgint}(f^{-1}(B))$ for each IFS B in Y.

Then f is an intuitionistic fuzzy contra weakly generalized irresolute mapping.

Proof.

(i) ⇒ (ii): Let B be an IFS in Y. By hypothesis we have,

$$f(\text{wgcl}(f^{-1}(B))) \subseteq \text{wgint}(f(f^{-1}(B))) \subseteq \text{wgint}(B).$$

This implies $\text{wgcl}(f^{-1}(B)) \subseteq f^{-1}(\text{wgint}(B))$.

(ii) ⇒ (iii): It can be proved by taking complement in (ii).

Suppose that (iii) holds. Let B be an IFWGCS in Y. By our assumption, we have

$$f^{-1}(B) \subseteq f^{-1}(\text{wgcl}(B)) \subseteq \text{wgint}(f^{-1}(B)) \subseteq f^{-1}(B).$$

Hence $\text{wgint}(f^{-1}(B)) = f^{-1}(B)$. This implies $f^{-1}(B)$ is an IFWGOS in X. Hence f is an intuitionistic fuzzy contra weakly generalized irresolute mapping. □

Theorem 3.10. Let $f : (X, \tau) \to (Y, \sigma)$ and $g : (Y, \sigma) \to (Z, \delta)$ be any two mappings. If $g_\circ f : (X, \tau) \to (Z, \delta)$ is an intuitionistic fuzzy contra weakly generalized irresolute mapping and (X, τ) is an $\mathrm{IF_{wg}T_{1/2}}$ space, then

(i) $(g_\circ f)^{-1}(B)$ is an IFWGOS in X for every IFWGCS B in Z.

(ii) $\mathrm{cl}(g_\circ f)^{-1}(\mathrm{int}(B)) \subseteq (g_\circ f)^{-1}(B)$ for every IFS B in Z.

Proof.

(i) Let B be an IFWGCS in Z. Then B^c is an IFWGOS in Z. By hypothesis, B^c is an IFWGCS in X. This implies B is an IFWGOS in X.

(ii) Let B be any IFS in Z and $\mathrm{int}(B) \subseteq B$. Then $(g_\circ f)^{-1}(\mathrm{int}(B)) \subseteq (g_\circ f)^{-1}(B)$. Since $\mathrm{int}(B)$ is an IFOS in Z, $\mathrm{int}(B)$ is an IFWGOS in Z. Then $(g_\circ f)^{-1}(\mathrm{int}(B))$ is an IFWGCS in X, by hypothesis. Since (X, τ) is an $\mathrm{IF_{wg}T_{1/2}}$ space, $(g_\circ f)^{-1}(\mathrm{int}(B))$ is an IFCS in X. Hence $\mathrm{cl}(g_\circ f)^{-1}(\mathrm{int}(B)) = (g_\circ f)^{-1}(\mathrm{int}(B)) \subseteq (g_\circ f)^{-1}(B)$. Therefore $\mathrm{cl}(g_\circ f)^{-1}(\mathrm{int}(B)) \subseteq (g_\circ f)^{-1}(B)$ for every IFS B in Z. □

Theorem 3.11. The composition of two intuitionistic fuzzy contra weakly generalized irresolute mappings is an intuitionistic fuzzy weakly generalized irresolute mapping in general.

Proof. Let $f : (X, \tau) \to (Y, \sigma)$ and $g : (Y, \sigma) \to (Z, \delta)$ be any two intuitionistic fuzzy contra weakly generalized irresolute mappings. Let A be an IFWGCS in Z. By hypothesis, $g^{-1}(A)$ is an IFWGOS in Y. Since f is an intuitionistic fuzzy contra weakly generalized irresolute mapping, $f^{-1}(g^{-1}(A)) = (g_\circ f)^{-1}(A)$ is an IFWGCS in X. Hence $g_\circ f : (X, \tau) \to (Z, \delta)$ is an intuitionistic fuzzy weakly generalized irresolute mapping. □

Theorem 3.12: Let $f : (X, \tau) \to (Y, \sigma)$ and $g : (Y, \sigma) \to (Z, \delta)$ be any two mappings. Then the following statements hold.

(i) If $f : (X, \tau) \to (Y, \sigma)$ is an intuitionistic fuzzy contra weakly generalized irresolute mapping and $g : (Y, \sigma) \to (Z, \delta)$ an intuitionistic fuzzy contra weakly generalized continuous mapping then $g_\circ f : (X, \tau) \to (Z, \delta)$ is an IFWG continuous mapping.

(ii) If $f : (X, \tau) \to (Y, \sigma)$ is an IFWG irresolute mapping and $g : (Y, \sigma) \to (Z, \delta)$ an intuitionistic fuzzy contra weakly generalized irresolute mapping then $g_\circ f : (X, \tau) \to (Z, \delta)$ is an intuitionistic fuzzy contra weakly generalized irresolute mapping.

(iii) If $f : (X, \tau) \to (Y, \sigma)$is an intuitionistic fuzzy contra weakly generalized irresolute mapping and $g : (Y, \sigma) \to (Z, \delta)$ an IFWG irresolute mapping then $g_\circ f : (X, \tau) \to (Z, \delta)$ is an intuitionistic fuzzy contra weakly generalized irresolute mapping.

(iv) If $f : (X, \tau) \to (Y, \sigma)$ is an intuitionistic fuzzy perfectly weakly generalized continuous mapping and $g : (Y, \sigma) \to (Z, \delta)$ an intuitionistic fuzzy contra weakly generalized irresolute mapping then $g_\circ f : (X, \tau) \to (Z, \delta)$ is an intuitionistic fuzzy perfectly weakly generalized continuous mapping.

(v) If $f : (X, \tau) \to (Y, \sigma)$ be an intuitionistic fuzzy contra weakly generalized irresolute mapping and $g : (Y, \sigma) \to (Z, \delta)$ an intuitionistic fuzzy perfectly weakly generalized continuous mapping then $g_\circ f : (X, \tau) \to (Z, \delta)$ is an intuitionistic fuzzy contra weakly generalized irresolute mapping and IFWG irresolute mapping.

Proof.

(i) Let A be an IFCS in Z. By hypothesis, $g^{-1}(A)$ is an IFWGOS in Y. Since f is an intuitionistic fuzzy contra weakly generalized irresolute mapping, $f^{-1}(g^{-1}(A)) = (g_\circ f)^{-1}(A)$ is an IFWGCS in X. Hence $g_\circ f : (X, \tau) \to (Z, \delta)$ is an IFWG continuous mapping.

(ii) Let A be any IFWGOS in Z. By hypothesis, $g^{-1}(A)$ is an IFWGCS in Y. Since f is an IFWG irresolute mapping, $f^{-1}(g^{-1}(A)) = (g_\circ f)^{-1}(A)$ is an IFWGCS in X. Hence $g_\circ f : (X, \tau) \to (Z, \delta)$ is an intuitionistic fuzzy contra weakly generalized irresolute mapping.

(iii) Let A be any IFWGOS in Z. By hypothesis, $g^{-1}(A)$ is an IFWGOS in Y. Since f is an intuitionistic fuzzy contra weakly generalized irresolute mapping, $f^{-1}(g^{-1}(A)) = (g_\circ f)^{-1}(A)$ is an IFWGCS in X. Hence $g_\circ f : (X, \tau) \to (Z, \delta)$ is an intuitionistic fuzzy contra weakly generalized irresolute mapping.

(iv) Let A be an IFWGOS in Z. By hypothesis, $g^{-1}(A)$ is an IFWGCS in Y. Since f is an intuitionistic fuzzy perfectly weakly generalized continuous mapping, $f^{-1}(g^{-1}(A)) = (g_\circ f)^{-1}(A)$ is an intuitionistic fuzzy clopen set in X. Hence $g_\circ f : (X, \tau) \to (Z, \delta)$ is an intuitionistic fuzzy perfectly weakly generalized continuous mapping.

(v) Let A be an IFWGOS in Z. By hypothesis, $g^{-1}(A)$ is an intuitionistic fuzzy clopen set in Y. Since every IFCS is an IFWGCS, $g^{-1}(A)$ is both IFWGCS and IFWGOS in Y. Since f is an intuitionistic fuzzy contra weakly generalized irresolute mapping, then $f^{-1}(g^{-1}(A)) = (g_\circ f)^{-1}(A)$ is both IFWGCS and IFWGOS in X. Hence $g_\circ f : (X, \tau) \to (Z, \delta)$ is an intuitionistic fuzzy contra weakly generalized irresolute and IFWG irresolute mapping. ☐

Definition 3.13. A mapping $f : (X, \tau) \to (Y, \sigma)$ is called an *intuitionistic fuzzy perfectly contra weakly generalized irresolute mapping* if $f^{-1}(B)$ is an intuitionistic fuzzy weakly generalized clopen set in (X, τ) for every IFWGOS B in (Y, σ).

Theorem 3.14. If $f : (X, \tau) \to (Y, \sigma)$ is an intuitionistic fuzzy perfectly contra weakly generalized irresolute mapping then f is an intuitionistic fuzzy contra weakly generalized irresolute mapping.

Proof. Let f be an intuitionistic fuzzy perfectly contra weakly generalized irresolute mapping. Let A be an IFWGOS in Y. By hypothesis, $f^{-1}(A)$ is intuitionistic fuzzy weakly generalized clopen set in X. Thus $f^{-1}(A)$ is an IFWGCS in X. Hence f is an intuitionistic fuzzy contra weakly generalized irresolute mapping. ☐

Theorem 3.15. Let $f : (X, \tau) \to (Y, \sigma)$ be a mapping from an IFTS (X, τ) into an IFTS (Y, σ). Then the following statements are equivalent.

(i) f is an intuitionistic fuzzy perfectly contra weakly generalized irresolute mapping.

(ii) f is intuitionistic fuzzy contra weakly generalized irresolute and IFWG irresolute mapping.

Proof.

(i) $\Rightarrow$ (ii): Let f be an intuitionistic fuzzy perfectly contra weakly generalized irresolute mapping. Let B be an IFWGOS in Y. By hypothesis, $f^{-1}(B)$ is an intuitionistic fuzzy weakly generalized clopen set in X. Thus $f^{-1}(B)$ is both IFWGOS and IFWGCS in X. Hence f is an intuitionistic fuzzy contra weakly generalized irresolute and IFWG irresolute mapping.

(ii) ⇒ (i): Let f be both intuitionistic fuzzy contra weakly generalized irresolute and IFWG irresolute mapping. Let B be an IFWGOS in Y. By hypothesis, $f^{-1}(B)$ is both IFWGOS and IFWGCS in X. That is, $f^{-1}(B)$ is intuitionistic fuzzy weakly generalized clopen set in X. Hence f is an intuitionistic fuzzy perfectly contra weakly generalized irresolute mapping. □

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