

Intuitionistic Fuzzy Supra Contra α - Continuity

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Abstract: In this present paper, we introduce a new class of mappings called intuitionistic fuzzy supra contra α - continuous. Some of its basic properties have been investigated. This class has been compared with other existing classes of mappings. By means of a suitable example, it is shown that composition of two intuitionistic fuzzy supra contra α - continuous is not an intuitionistic fuzzy supra contra α - continuous.

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Introduction

The concept of intuitionistic fuzzy set has been defined by Atanassov[1] in1986 as a generalization of fuzzy set given by Zadeh [7]. Using intuitionistic fuzzy sets, Coker [2] originated the concept of intuitionistic fuzzy topological spaces. In 1999, Necla Turanh [5] introduced the concept of intuitionistic fuzzy supra topological space. Later on, many researchers studied some kinds of mappings in intuitionistic fuzzy supra topological spaces .In this paper, we are going to introduce the notion of intuitionistic fuzzy supra contra α -continuous functions and study their basic properties. Throughout this paper, we denote the intuitionistic fuzzy supra topological space(briefly,IFSTS) by (X, τ) or simply X.

Preliminaries

Definition 2.1[1] Let X be a non-empty fixed set and I be the closed interval $[0, 1]$. An intuitionistic fuzzy set

(in short IFS) A is an object of the form $A = \{\langle x, \mu_A(x), \gamma_A(x) : x \in X \rangle\}$ where the mappings $\mu_A : X \rightarrow [0,1]$ and $\gamma_A : X \rightarrow [0,1]$ denote the degree of membership (namely $\mu_A(x)$) and the degree of non-membership (namely $\gamma_A(x)$) for each element $x \in X$ to the set A respectively, and $0 \leq \mu_A(x) + \gamma_A(x) \leq 1$ for each $x \in X$.

Clearly, every fuzzy set A on a non-empty set X is an intuitionistic fuzzy set of the following form

$$A = \{\langle x, \mu_A(x), 1 - \mu_A(x) \rangle : x \in X \} .$$

Definition 2.2 [1] Let A and B are intuitionistic fuzzy sets of the form

$$A = \{\langle x, \mu_A(x), \gamma_A(x) \rangle : x \in X \} \text{ and}$$

$$B = \{\langle x, \mu_B(x), \gamma_B(x) \rangle : x \in X \} .$$
 Then

(i) $A \subseteq B$ if and only if $\mu_A(x) \leq \mu_B(x)$ and $\gamma_A(x) \geq \gamma_B(x)$;

(ii) $\bar{A} = \{\langle x, \gamma_A(x), \mu_A(x) \rangle : x \in X \}$;

(iii)

$$A \cap B = \{\langle x, \mu_A(x) \cap \mu_B(x), \gamma_A(x) \cup \gamma_B(x) \rangle : x \in X \}$$

(iv)

$$A \cup B = \{\langle x, \mu_A(x) \cup \mu_B(x), \gamma_A(x) \cap \gamma_B(x) \rangle : x \in X \}$$

;

(v) $A = B$ iff $A \subseteq B$ and $B \subseteq A$.

Definition 2.3[5] A family τ of intuitionistic fuzzy set's on X is called an intuitionistic fuzzy supra topology(in short,IFST) on X if $\tilde{0} \in \tau$, $\tilde{1} \in \tau$ and τ is closed under arbitrary suprema. Then we call the pair (X, τ) an intuitionistic fuzzy supra topological space (in short,IFSTS). Each member of τ is called an intuitionistic fuzzy supra open set and the complement of an intuitionistic fuzzy supra open set is called an intuitionistic fuzzy supra closed set. The intuitionistic fuzzy supra closure of IFS A is denoted by $s-cl(A)$. Here, $s-cl(A)$ is the intersection of all intuitionistic fuzzy supra closed sets containing A . The intuitionistic fuzzy supra interior of A will be denoted by $s-int(A)$.

Here, $s-int(A)$ is the union of all intuitionistic fuzzy supra open sets contained in A .

Definition 2.4[6] Let (X, τ) be an intuitionistic fuzzy supra topological space. An intuitionistic fuzzy set A in $IF(X)$ is called intuitionistic fuzzy α - supra open iff

$$A \subseteq s-int(s-cl(s-int(A))) .$$
 The

complement of intuitionistic fuzzy α - supra open

set is called an intuitionistic fuzzy α - supra closed set.

Definition 2.5 [6] Let f be a mapping from an ordinary set X into an ordinary set Y , if

$$B = \{ \langle y, \mu_B(y), \gamma_B(y) \rangle : y \in Y \}$$

is an intuitionistic fuzzy set in Y , then the inverse image of B under f is an intuitionistic fuzzy set defined by $f^{-1}(B)$

$$= \{ \langle x, f^{-1}(\mu_B(x)), f^{-1}(\gamma_B(x)) \rangle : x \in X \}.$$

The image of intuitionistic fuzzy set

$$A = \{ \langle y, \mu_A(y), \gamma_A(y) \rangle : y \in Y \}$$

under f is defined by

$$f(A) = \{ \langle y, f(\mu_A(y)), f(\gamma_A(y)) \rangle : y \in Y \}.$$

Definition 2.6[3] Let (X, τ) and (Y, σ) be two intuitionistic fuzzy supra topological spaces. A map $f : (X, \tau) \rightarrow (Y, \sigma)$ is called intuitionistic fuzzy supra contra continuous map if the inverse image of each intuitionistic fuzzy supra open set in Y is intuitionistic fuzzy supra closed in X .

Definition 2.7[3] Let (X, τ) and (Y, σ) be two intuitionistic fuzzy supra topological spaces. A map $f : (X, \tau) \rightarrow (Y, \sigma)$ is called intuitionistic fuzzy α -supra continuous map if the inverse image of each intuitionistic fuzzy supra open set in Y is intuitionistic fuzzy α - supra open in X .

Definition 2.8[4] Let $f : (X, \tau) \rightarrow (Y, \sigma)$ be a mapping from an intuitionistic fuzzy topological space X into an intuitionistic fuzzy topological space Y . The mapping f is called an intuitionistic fuzzy contra α - continuous, if $f^{-1}(B)$ is an intuitionistic fuzzy α - closed set in X , for each intuitionistic fuzzy open set B in Y .

Definition 2.9[4] The intuitionistic fuzzy α - supra interior of a set A is denoted by $\alpha s - \text{int} (A) = \bigcup \{ G : G \text{ is an intuitionistic fuzzy } \alpha \text{ - supra open set in } X \text{ and } G \subseteq A \}$ and the intuitionistic fuzzy α - supra closure of a set A is denoted by $\alpha s - cl (A) = \bigcap \{ G : G \text{ is an intuitionistic fuzzy } \alpha \text{ - supra closed set in } X \text{ and } G \supseteq A \}$.

Remark 2.10[4] $\alpha s - \text{int} (A)$ is an intuitionistic fuzzy supra open set and $\alpha s - cl (A)$ is an intuitionistic fuzzy α supra closed set.

Theorem 2.11[4] Every intuitionistic fuzzy supra open set is intuitionistic fuzzy α - supra open set.

Theorem 2.12[4] Every intuitionistic fuzzy closed set is intuitionistic fuzzy supra closed set.

Theorem 2.13[2] Let A, A_1, A_2 and B, B_1, B_2 be an intuitionistic fuzzy sets in X and Y respectively and $f : (X, \tau) \rightarrow (Y, \sigma)$ be a function. Then

- (i) $A_1 \subseteq A_2 \Rightarrow f(A_1) \subseteq f(A_2)$,
- (ii) $B_1 \subseteq B_2 \Rightarrow f^{-1}(B_1) \subseteq f^{-1}(B_2)$,
- (iii) $A \subseteq f^{-1}(f(A))$ and if f is injective, then $A = f^{-1}(f(A))$,
- (iv) $f(f^{-1}(B)) \subseteq B$ and if f is surjective, then $B = f(f^{-1}(B))$,
- (v) $f^{-1}(B^c) = (f^{-1}(B))^c$.

3 Intuitionistic fuzzy supra contra α - continuous

Definition 3.1 Let (X, τ) and (Y, σ) be intuitionistic fuzzy supra topological spaces. A map $f : (X, \tau) \rightarrow (Y, \sigma)$ is called an intuitionistic fuzzy supra contra α - continuous map if the pre-image of each intuitionistic fuzzy supra open set in Y is intuitionistic fuzzy α - supra closed in X .

Example 3.2 Let $X = \{a, b\}$, $Y = \{p, q\}$,
 $A = \{ \langle a, 0.4, 0.6 \rangle, \langle b, 0.5, 0.4 \rangle \}$,
 $B = \{ \langle a, 0.3, 0.7 \rangle, \langle b, 0.6, 0.3 \rangle \}$,
 $C = \{ \langle a, 0.4, 0.6 \rangle, \langle b, 0.6, 0.3 \rangle \}$, and
 $D = \{ \langle p, 0.6, 0.4 \rangle, \langle q, 0.4, 0.5 \rangle \}$. Consider $\tau = \{ \tilde{0}, A, B, C, \tilde{1} \}$ and $\sigma = \{ \tilde{0}, D, \tilde{1} \}$. Now, (X, τ) and (Y, σ) are intuitionistic fuzzy supra topological spaces. A mapping $f : (X, \tau) \rightarrow (Y, \sigma)$, that is defined by $f(a) = p, f(b) = q$ is an intuitionistic fuzzy supra contra α - continuous map.

Theorem 3.3 A map $f : (X, \tau) \rightarrow (Y, \sigma)$ is an intuitionistic fuzzy supra contra α - continuous iff pre-image of each intuitionistic fuzzy supra closed set in (Y, σ) is an intuitionistic fuzzy α - supra open set in (X, τ) .

Proof. Assume that f is an intuitionistic fuzzy supra contra α - continuous map. Let F be any intuitionistic fuzzy supra closed set in (Y, σ) . Then, F^c is an intuitionistic fuzzy supra open set in (Y, σ) . By hypothesis, $f^{-1}(F^c)$ is an intuitionistic fuzzy α - supra closed set in (X, τ) . By [3], $(f^{-1}(F))^c$ is intuitionistic fuzzy α -supra closed set in (X, τ) . By [6], $f^{-1}(F)$ is an intuitionistic fuzzy α - supra open set in (X, τ) . Hence the inverse image of each intuitionistic fuzzy supra closed set in (Y, σ) is an intuitionistic fuzzy α - supra open set in (X, τ) .

conversely, Assume the given hypothesis. Let V be any intuitionistic fuzzy supra open set in (Y, σ) . Then, V^c is an intuitionistic fuzzy supra closed set in (Y, σ) . By hypothesis and [3], $f^{-1}(V^c) = (f^{-1}(V))^c$ is an intuitionistic fuzzy α - supra open set in (X, τ) . By [4], $f^{-1}(V)$ is an intuitionistic fuzzy α - supra closed set in (X, τ) . Hence f is an intuitionistic fuzzy supra contra α - continuous map.

Theorem 3.4 Let $f : (X, \tau) \rightarrow (Y, \sigma)$ be a bijective mapping from an intuitionistic fuzzy supra topological space X into an intuitionistic fuzzy supra topological space Y . suppose that one of the following properties hold.

1. $f^{-1}(\alpha s - cl(B)) \subseteq \alpha s - int(\alpha s - cl(f^{-1}(B)))$ for each intuitionistic fuzzy set B in (Y, σ) .
2. $\alpha s - cl(\alpha s - int(f^{-1}(B))) \subseteq f^{-1}(\alpha s - int(B))$ for each intuitionistic fuzzy set B in (Y, σ) .
3. $f(\alpha s - cl(\alpha s - intA)) \subseteq \alpha s - int(f(A))$ for each intuitionistic fuzzy set A in (X, τ) .
4. $f(\alpha s - cl(A)) \subseteq \alpha s - int(f(A))$ for each intuitionistic fuzzy α -supra open set A in (X, τ) . Then, f is an intuitionistic fuzzy supra contra α - continuous map.

Proof. $1 \Rightarrow 2$: It holds by applying 1 for the complement set.

$2 \Rightarrow 3$: Let A be any intuitionistic fuzzy set in (X, τ) . Let $B = f(A) \subseteq Y$. Since f is injective, $A = f^{-1}(f(A)) = f^{-1}(B)$. By hypothesis, $\alpha s - cl(\alpha s - int(f^{-1}(B))) \subseteq f^{-1}(\alpha s - int(B))$.

Therefore, $f(\alpha s - cl(\alpha s - intA)) \subseteq \alpha s - int(f(A))$.

$3 \Rightarrow 4$: Let A be any intuitionistic fuzzy α - supra open set in (X, τ) . By [4], $\alpha s - int(A) = A$.

By hypothesis, $f(\alpha s - cl(\alpha s - int(A))) \subseteq \alpha s - int(f(A))$.

Therefore, $f(\alpha s - cl(A)) \subseteq \alpha s - int(f(A))$.

$4 \Rightarrow f$ is an intuitionistic fuzzy supra contra α - continuous: Let B be any intuitionistic fuzzy supra open set in (Y, σ) . Since f is bijective, there exists $A \subseteq X$ such that

$A = f^{-1}(f(A)) = f^{-1}(B)$. By hypothesis, $f(\alpha s - cl(A)) \subseteq \alpha s - int(f(A))$. Then, $f(\alpha s - cl(f^{-1}(B))) \subseteq \alpha s - int(f(f^{-1}(B))) = \alpha s - int(B) = B$.

Therefore, $\alpha s - cl(f^{-1}(B)) \subseteq f^{-1}(B)$. Always, $f^{-1}(B) \subseteq \alpha s - cl(f^{-1}(B))$. Then,

$f^{-1}(B) = \alpha s - cl(f^{-1}(B))$. Therefore, $f^{-1}(B)$ is intuitionistic fuzzy α - supra closed in (X, τ) .

Hence f is an intuitionistic fuzzy supra contra α - continuous map.

Theorem 3.5 A map $f : (X, \tau) \rightarrow (Y, \sigma)$ be any mapping from an intuitionistic fuzzy supra topological space X into an intuitionistic fuzzy supra topological space Y . suppose that one of the following properties hold:

1. $f(\alpha s - cl(A)) \subseteq \alpha s - int(f(A))$ for each intuitionistic fuzzy set A in X .
 2. $\alpha s - cl(f^{-1}(B)) \subseteq f^{-1}(\alpha s - int(B))$ for each intuitionistic fuzzy set B in Y .
 3. $f^{-1}(\alpha s - cl(B)) \subseteq \alpha s - int(f^{-1}(B))$ for each intuitionistic fuzzy set B in Y .
- Then, f is an intuitionistic fuzzy supra contra α - continuous.

Proof. $1 \Rightarrow 2$ Let B be any intuitionistic fuzzy supra set in Y . Now, $f^{-1}(B) = A \subseteq X$. By hypothesis,

$$f(\alpha s - cl(f^{-1}(B))) \subseteq s - int(f(f^{-1}(B)))$$

$$\subseteq s - int(B).$$

Thus,

$$\alpha s - cl(f^{-1}(B)) \subseteq f^{-1}(f(\alpha s - cl(f^{-1}(B))))$$

$$f^{-1}(s - int(B)).$$

2 \Rightarrow 3 It holds by applying 2 for the complement set.

3 \Rightarrow f is an intuitionistic fuzzy supra contra α - continuous: Let B be any intuitionistic fuzzy supra closed set in (Y, σ) . Then, $B = s - cl(B)$. By hypothesis,

$$f^{-1}(B) = f^{-1}(s - cl(B)) \subseteq \alpha s - int(f^{-1}(B)).$$

Thus, $f^{-1}(B) \subseteq \alpha s - int(f^{-1}(B))$. Always,

$$\alpha s - int(f^{-1}(B)) \subseteq f^{-1}(B). \text{ Therefore,}$$

$f^{-1}(B) = \alpha s - int(f^{-1}(B))$ and so, $f^{-1}(B)$ is an intuitionistic fuzzy α -supra open set in (X, τ) .

Hence f is an intuitionistic fuzzy supra contra α - continuous.

Theorem 3.6 Let $f : (X, \tau) \rightarrow (Y, \sigma)$ be a bijective mapping from an intuitionistic fuzzy supra topological space X into an intuitionistic fuzzy supra topological space Y . The mapping f is an intuitionistic fuzzy supra contra α - continuous if $s - cl(f(A)) \subseteq f(\alpha s - int(A))$ for each intuitionistic fuzzy set A in X.

Proof. Let B be any intuitionistic fuzzy supra closed set in (Y, σ) . Since f is surjective,

$$B = f(A), \text{ for some } A \subseteq X. \text{ Now,}$$

$$A = f^{-1}(f(A)) = f^{-1}(B) \subseteq X.$$

By hypothesis,

$$B = s - cl(B) \subseteq f(\alpha s - int(f^{-1}(B))). \text{ Thus,}$$

$$f^{-1}(B) \subseteq \alpha s - int(f^{-1}(B)). \text{ Always,}$$

$$\alpha s - int(f^{-1}(B)) \subseteq f^{-1}(B). \text{ Therefore,}$$

$$f^{-1}(B) = \alpha s - int(f^{-1}(B)). \text{ Hence, } f^{-1}(B) \text{ is}$$

an intuitionistic fuzzy α - supra open set in (X, τ) . Thus, f is an intuitionistic fuzzy supra contra α -continuous function.

Theorem 3.7 Every intuitionistic fuzzy supra contra continuous is an intuitionistic fuzzy supra contra α - continuous.

Proof. Let A be any intuitionistic fuzzy supra open set in (Y, σ) . By hypothesis, $f^{-1}(A)$ is an intuitionistic fuzzy supra closed set in (Y, σ) . By

[4], $f^{-1}(A)$ is intuitionistic fuzzy α - supra closed set. Thus, f is an intuitionistic fuzzy supra contra α - continuous.

Remark 3.8. In general, converse is not true. It is illustrated in the following example.

Example 3.9. Let $X = \{a, b\}, Y = \{p, q\},$
 $A = \{\langle a, 0.6, 0.3 \rangle, \langle b, 0.4, 0.3 \rangle\},$
 $B = \{\langle a, 0.4, 0.3 \rangle, \langle b, 0.6, 0.2 \rangle\},$
 $C = \{\langle a, 0.6, 0.3 \rangle, \langle b, 0.6, 0.2 \rangle\}$ and
 $D = \{\langle p, 0.1, 0.7 \rangle, \langle q, 0.2, 0.6 \rangle\}.$ Consider
 $\tau = \{\tilde{0}, A, B, C, \tilde{1}\}$ and $\sigma = \{\tilde{0}, D, \tilde{1}\}.$ Now,
 (X, τ) and (Y, σ) are intuitionistic fuzzy supra topological spaces. A mapping
 $f : (X, \tau) \rightarrow (Y, \sigma),$ that is defined by
 $f(a) = p, f(b) = q,$ is an intuitionistic fuzzy supra contra α - continuous but not an intuitionistic fuzzy supra contra continuous .

Theorem 3.10 Every intuitionistic fuzzy supra contra continuous is intuitionistic fuzzy supra contra continuous.

Proof Let B be any intuitionistic fuzzy open set in (Y, σ) . By hypothesis, $f^{-1}(B)$ is intuitionistic fuzzy closed set in (X, τ) . By [4], $f^{-1}(B)$ is intuitionistic fuzzy supra closed set in (X, τ) . Therefore, f is intuitionistic fuzzy supra contra continuous.

Compositions:

Remark 3.11 Composition of two intuitionistic fuzzy supra contra α - continuous mappings is not an intuitionistic fuzzy supra contra α - continuous. It is discussed in the following example.

Example 3.12 Let $X = \{a, b\}, Y = \{u, v\},$
 $A = \{\langle a, 0.3, 0.5 \rangle, \langle b, 0.6, 0.4 \rangle\},$
 $B = \{\langle a, 0.2, 0.4 \rangle, \langle b, 0.7, 0.3 \rangle\},$
 $C = \{\langle a, 0.3, 0.4 \rangle, \langle b, 0.7, 0.3 \rangle\}$ and
 $P = \{\langle u, 0.4, 0.2 \rangle, \langle v, 0.3, 0.7 \rangle\}.$ Consider
 $\tau = \{\tilde{0}, A, B, C, \tilde{1}\}$ and $\sigma = \{\tilde{0}, P, \tilde{1}\}.$ Now,
 (X, τ) and (Y, σ) are intuitionistic fuzzy supra topological spaces. A mapping
 $f : (X, \tau) \rightarrow (Y, \sigma),$ that is defined by
 $f(a) = u, f(b) = v,$ is an intuitionistic fuzzy supra contra α - continuous mapping. Let

$z = \{r, s\}$, $Q = \{\langle r, 0.2, 0.4 \rangle, \langle s, 0.7, 0.3 \rangle\}$ and $\eta = \{\tilde{0}, Q, \tilde{1}\}$. Then (Z, η) is an intuitionistic fuzzy supra topological space. A mapping $g : (Y, \sigma) \rightarrow (Z, \eta)$, that is defined by $g(u) = r, g(v) = s$, is an intuitionistic fuzzy supra contra α -continuous mapping. Here, $g \circ f : (X, \tau) \rightarrow (Z, \eta)$ defined by $(g \circ f)(x) = g(f(x))$ for all $x \in X$ is not an intuitionistic fuzzy supra contra α -continuous.

Theorem 3.13 If $f : (X, \tau) \rightarrow (Y, \sigma)$ is intuitionistic fuzzy supra continuous mapping and $g : (Y, \sigma) \rightarrow (Z, \eta)$ is intuitionistic fuzzy supra contra continuous mapping, then $g \circ f : (X, \tau) \rightarrow (Z, \eta)$ is intuitionistic fuzzy supra contra α -continuous mapping.

Proof. Let A be any intuitionistic fuzzy supra open set in (Z, η) . Since, g is an intuitionistic fuzzy supra contra continuous mapping, $g^{-1}(A)$ is intuitionistic fuzzy supra closed set in (Y, σ) . Since, f is an intuitionistic fuzzy supra continuous mapping, $f^{-1}(g^{-1}(A)) = (g \circ f)^{-1}(A)$ is intuitionistic fuzzy supra closed set in (X, τ) . By [4], $(g \circ f)^{-1}(A)$ intuitionistic fuzzy α -supra closed set in (X, τ) . Therefore, $g \circ f$ is intuitionistic fuzzy supra contra α -continuous mapping.

Theorem 3.14 If $f : (X, \tau) \rightarrow (Y, \sigma)$ is an intuitionistic fuzzy supra contra α -continuous mapping and $g : (Y, \sigma) \rightarrow (Z, \eta)$ is an intuitionistic fuzzy supra continuous mapping, then $g \circ f : (X, \tau) \rightarrow (Z, \eta)$ is intuitionistic fuzzy supra contra α -continuous mapping.

Proof. Let A be any intuitionistic fuzzy supra open set in (Z, η) . Since g is intuitionistic fuzzy supra continuous mapping, $g^{-1}(A)$ is an intuitionistic fuzzy supra open set in (Y, σ) . Since f is intuitionistic fuzzy supra contra α -continuous mapping, $f^{-1}(g^{-1}(A)) = (g \circ f)^{-1}(A)$ is intuitionistic fuzzy α -supra closed set in (X, τ) . Therefore, $g \circ f$ is an intuitionistic fuzzy supra contra α -continuous mapping.

Theorem 3.15 If $f : (X, \tau) \rightarrow (Y, \sigma)$ is an intuitionistic fuzzy α -supra continuous mapping and $g : (Y, \sigma) \rightarrow (Z, \eta)$ is an intuitionistic fuzzy supra contra continuous mapping, then $g \circ f : (X, \tau) \rightarrow (Z, \eta)$ is an intuitionistic fuzzy supra contra α -continuous mapping.

Proof. Let A be any intuitionistic fuzzy supra open set in (Z, η) . Since g is an intuitionistic fuzzy supra contra continuous mapping, $g^{-1}(A)$ is intuitionistic fuzzy supra closed set in (Y, σ) . Since f is an intuitionistic fuzzy α -supra continuous mapping, $f^{-1}(g^{-1}(A)) = (g \circ f)^{-1}(A)$ is intuitionistic fuzzy α -supra closed set in (X, τ) . Therefore, $g \circ f$ is an intuitionistic fuzzy supra contra α -continuous mapping.

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