

INTUITIONISTIC FUZZY SOFT CONTRA GENERALIZED B-CONTINUOUS FUNCTIONS



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ABSTRACT

The main focus of this paper is to introduce the concept of intuitionistic fuzzy soft contra generalized b-continuous functions and intuitionistic fuzzy soft almost generalized b-continuous functions in intuitionistic fuzzy soft topological space. We further studied and established the properties of intuitionistic fuzzy soft contra gb-continuous functions and intuitionistic fuzzy soft almost generalized b-continuous functions in intuitionistic fuzzy soft topological space.

Keywords: Intuitionistic Fuzzy Soft Set, Intuitionistic Fuzzy Soft Topology, Intuitionistic Fuzzy Soft Generalized B-Closed Set, Intuitionistic Fuzzy Soft Generalized B-Continuous Functions, Intuitionistic Fuzzy Soft Contra Generalized B-Continuous Functions, Intuitionistic Fuzzy Soft Almost Generalized B-Continuous Functions

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1. INTRODUCTION

In this paper we define intuitionistic fuzzy soft generalized contra b-continuous functions and intuitionistic fuzzy soft almost generalized b-continuous functions and the properties are discussed.

A number of theories such as the theory of fuzzy sets, theory of intuitionistic fuzzy sets and theory of vague sets have been proposed for dealing with uncertainties in an efficient way and all these have their own difficulties. In 1999 Molodtsov [Molodtsov \(1999\)](#) introduce the concept of soft set theory for vagueness. Later in 2001, MAji. P. K., R. Biswas and A. R. Roy [Maji et al. \(2001\)](#) introduced the intuitionistic fuzzy soft sets. Moreover, Li and Cui [Li et al. \(2013\)](#) introduced the fundamental concepts of intuitionistic fuzzy soft topology in 2012. Also, the concept of intuitionistic fuzzy soft b-closed sets is introduced by Shuker Mahmood Khalil [Khalil \(2015\)](#) in 2014. Ahmed Al Omari and Mohd. Salmi Md. Noorani [Al-Omari et al. \(2009\)](#) studied the class of generalized b-closed sets. Dontchev [Dontchev \(1996\)](#) introduced the notion of contra-continuity and obtained some results compactness etc.

2. PRELIMINARIES

Definition:1.1 Osmanoglu and Tokat (2013) Let U be an initial set and E be the set of parameters. Let IF^U denote the collection of all IF subsets of U . Let $A \subseteq E$. A pair (F, A) is called an IF soft set over U where F is a mapping given by $F : A \rightarrow IF^U$.

Definition:1.2 Osmanoglu and Tokat (2013) Let (F, A) and (G, B) be two IF soft sets over U .

(1). The union $(F, A) \cup (G, B) = (H, C)$ where $C = A \cup B$ and $\forall e \in C$

$$H(e) = \begin{cases} F(e) & \text{if } e \in A - B \\ G(e) & \text{if } e \in B - A \\ F(e) \cup G(e) & \text{if } e \in A \cap B \end{cases}$$

(2). The intersection

$(F, A) \cap (G, B) = (H, C)$ where $C = A \cap B$ and $\forall e \in C, H(e) = F(e) \cap G(e)$

(3). $(F, A) \subseteq (G, B)$ if $A \subseteq B$ and for all $e \in A, F(e) \subseteq G(e)$

(4). The complement of an intuitionistic fuzzy soft set (F, A) is denoted by $(F, A)^c$ and is defined by $(F, A)^c = (F^c, A)$, where $F^c : A \rightarrow IF^U$ is a mapping given by $F^c(e) = [F(e)]^c$ for all $e \in A$.

Thus if

$$F(e) = \{(x, \mu_{F(e)}(x), \nu_{F(e)}(x)) : x \in U\},$$

$$\text{then } \forall e \in A, F^c(e) = (F(e))^c = \{(x, \nu_{F(e)}(x), \mu_{F(e)}(x)) : x \in U\}$$

Definition:1.3 Osmanoglu and Tokat (2013) An IF soft set (F, A) over U is said to be absolute IF soft set denoted by \tilde{I}_e if for all $e \in A, F(e)$ is the IF absolute set \tilde{I} of U where $\tilde{I} = \{(x, 1, 0) : x \in U\}$

Definition:1.4 Osmanoglu and Tokat (2013) An IF soft set (F, A) over U is said to be null IF soft set denoted by $\tilde{\phi}_e$ if for all $e \in A, F(e)$ is the IF null set \tilde{O} of U where $\tilde{O} = \{(x, 0, 1) : x \in U\}$

Definition:1.5 Osmanoglu and Tokat (2013) Let $\tau \subseteq IFS(U, E)$, then is said to be an IF soft topology on U if the following conditions hold

1. $\tilde{\phi}_e$ and \tilde{I}_e belong to τ
2. The union of any number of IF soft sets in τ belongs to τ
3. The intersection of any two IF soft sets in τ belongs to τ

τ is called an IF soft topology over U and the triplet (U, τ, E) is called a IF soft topological space over U .

The members of τ are said to be IF soft open sets in U .

DEFINITION:1.6 Osmanoglu and Tokat (2013) An $(F, A) \in IFS(U, E)$ is called IF soft point if for the element $e \in A$, $F(e) \neq \phi$ and $F(e') = \phi$ for all $e' \in A \setminus \{e\}$ is denoted by e_F .

Definition:1.7 G et al. (2019) Let (U, τ, E) be an IF soft topological space over U and let (F, E) be an IF soft set over U . Then (F, E) is said to be intuitionistic fuzzy soft regular closed (briefly IFSrC) if $(F, E) =_{cl} (int(F, E))$

Definition:1.8 G et al. (2019) An IF soft set (F, E) of an IF soft topological space (U, τ, E) is called an IF soft generalized b-closed set (briefly IFSgbCS) if $bcl(F, E) \subseteq (G, B)$ whenever $(F, E) \subseteq (G, E)$ and (G, E) is IF soft open set in (U, τ, E)

Definition:1.9 G et al. (2019) An IF soft set (F, E) of an IF soft topological space (U, τ, E) is called IF soft g-open if $(F, E)^c$ is IF soft gb-closed in (U, τ, E)

The family of all IF soft gb-open sets in (U, τ, E) is denoted by IFSgbO .

Definition:1.10 Osmanoglu and Tokat (2013) Let $IFS(U_E)$ and $IFS(V_k)$ be two intuitionistic fuzzy soft classes, and let $\omega : U \rightarrow V$ and $\psi : E \rightarrow K$ be mappings. Then a mapping $\omega_\psi : IFS(U, E) \rightarrow IFS(V, K)$ is defined as: for $(F, A) \in IFS(U_E)$, the image of (F, A) under ω_ψ denoted by $\omega_\psi(F, A) = (\omega(F), \psi(A))$, is an IFS set in $IFS(V_k)$ given by

$$\mu_{\omega(F)(k)}(v) = \begin{cases} \sup_{e \in \psi^{-1}(k) \cap A, u \in \omega^{-1}(v)} \mu_{F(e)}(u) & \text{if } \omega^{-1}(v) \neq \phi, \\ 0 & \text{otherwise} \end{cases}$$

$$\nu_{\omega(F)(k)}(v) = \begin{cases} \inf_{e \in \psi^{-1}(k) \cap A, u \in \omega^{-1}(v)} \nu_{F(e)}(u) & \text{if } \omega^{-1}(v) \neq \phi, \\ 1 & \text{otherwise} \end{cases}$$

For all $k \in \psi(A)$ and $v \in V$.

For $(G, B) \in IFS(V_k)$ the inverse image of (G, B) under ω_ψ , denoted by is an IFS set in $IFS(U, E)$ given by $\mu_{\omega^{-1}(G)(e)}(u) = \mu_{G(\psi(e))}(\omega(u))$ and $\nu_{\omega^{-1}(G)(e)}(u) = \nu_{G(\psi(e))}(\omega(u))$ for all $e \in \psi^{-1}(B)$ and

Definition:1.11 G et al. (2021) Let (U, τ, E) and (V, τ', K) be two IF soft topological spaces over U and V respectively. Then the mapping $\omega_\psi : (U, \tau, E) \rightarrow (V, \tau', K)$ is called a IF soft gb-continuous (IFSgb-continuous) mapping if $(\omega_\psi)^{-1}(G, K)$ is an IF soft gb-closed set in for every IF soft closed set (U, τ, E) for every IF soft closed set (G, K) in (V, τ', K) .

Definition:1.12 G et al. (2021) Let (U, τ, E) and (V, τ', K) be two IF soft topological spaces over U and V respectively. Then the mapping $\omega_\psi : (U, \tau, E) \rightarrow (V, \tau', K)$ is called an IF soft gb-irresolute (IFSgb-irresolute) mapping if $(\omega_\psi)^{-1}(G, K)$ is an IF soft gb-closed set in (U, τ, E) for every IF soft gb-closed set (G, K) in (V, τ', K)

3. IF SOFT CONTRA GB-CONTINUOUS FUNCTION

Definition 3.1: Let (U, τ, E) and (V, τ', K) be any two IF soft topological spaces over U and V respectively. An IF soft function $\omega\psi : (U, \tau, E) \rightarrow (V, \tau', K)$ is said to be an

1. IF soft contra-continuous if $(\omega\psi)^{-1}(G, K)$ is an IF soft closed set in (U, τ, E) for every IF soft open set (G, K) in (V, τ', K)
2. IF soft contra b-continuous if $(\omega\psi)^{-1}(G, K)$ is an IF soft b-closed set in (U, τ, E) for every IF soft open set (G, K) in (V, τ', K)

Definition 3.2: Let (U, τ, E) and (V, τ', K) be any two IF soft topological spaces over U and V respectively. An IF soft function $\omega\psi : (U, \tau, E) \rightarrow (V, \tau', K)$ is said to be an IF soft contra if $(\omega\psi)^{-1}(G, K)$ is an IF soft gb-closed set in (U, τ, E) for every IF soft open set (G, K) in (V, τ', K) .

Definition 3.3: An IF soft topological space (U, τ, E) is called

1. IF soft gb-space if every IF soft gb-closed set is soft closed over U .
2. IF soft gb-locally indiscrete space if every IF soft gb-open set is soft closed over U .
3. IF soft semi-regular space if every IF soft closed set is soft regular closed over U .
4. IF soft T_{gb} -space if every IF soft gb-closed set is soft b-closed over U .
5. IF soft semi-gb space if every IF soft gb-closed set is soft regular closed over U .

Theorem 3.4:

1. Every IF soft contra continuous function is IF soft contra gb-continuous function.
2. Every IF soft contra b-continuous function is IF soft contra gb-continuous function.

Converse the above theorem need not be true.

Example 3.5:

1. Let $U = \{u_1, u_2\}$, $E = \{e_1, e_2\}$ and $V = \{v_1, v_2\}$, $K = \{k_1, k_2\}$.

Let $(F_1, E) = \{F_1(e_1) = \{(u_1, .6, .3); (u_2, .3, .5)\}, F_1(e_2) = \{(u_1, .4, .3); (u_2, .7, .2)\}\}$,

$(F_2, E) = \{F_2(e_1) = \{(u_1, .5, .4); (u_2, .2, .6)\}, F_2(e_2) = \{(u_1, .2, .5); (u_2, .6, .3)\}\}$ and

$(G_1, K) = \{G_1(k_1) = \{(v_1, .4, .5); (v_2, .6, .2)\}, G_1(k_2) = \{(v_1, .5, .4); (v_2, .4, .5)\}\}$.

Then $\tau = \{\tilde{\varphi}_e, (F_1, E), (F_2, E), \tilde{I}_e\}$ and $\tau' = \{\tilde{\varphi}_k, (G_1, K), \tilde{I}_k\}$ are IF soft topologies over U and V respectively. Define the mapping $\omega : V \rightarrow U$ by $\omega(v_1) = u_1, \omega(v_2) = u_2$ and $\psi : K \rightarrow E$ by $\psi(k_1) = e_1, \psi(k_2) = e_2$, then the mapping $\omega\psi : (V, \tau', K) \rightarrow (U, \tau, E)$ is IF soft contra gb-continuous mapping, but not an IF soft contra-continuous map, since for the IF soft open set $(G_1, K) = \{G_1(k_1) = \{(v_1, .4, .5); (v_2, .6, .2)\}, G_1(k_2) = \{(v_1, .5, .4); (v_2, .4, .5)\}\}, \omega\psi^{-1}(G_1, K)$ is not an IF soft closed set in (U, τ, E)

Example:ii

1. Let $U = \{u_1, u_2\}$, $E = \{e_1, e_2\}$ and $V = \{v_1, v_2\}$, $K = \{k_1, k_2\}$.

Let $(F_1, E) = \{F_1(e_1) = \{(u_1, .6, .3); (u_2, .3, .5), F_1(e_2) = \{(u_1, .4, .3); (u_2, .7, .2)\}$ and $(G_1, K) = \{G_1(k_1) = \{(v_1, .6, .3); (v_2, .5, .4), G_1(k_2) = \{(v_1, .4, .3); (v_2, .7, .1)\}$. Then $\tau = \{\tilde{\psi}_e, (F_1, E), \tilde{I}_e\}$ and $\tau' = \{\tilde{\varphi}_k, (G_1, K), \tilde{I}_k\}$ are IF soft topologies over U and V respectively. Define the mapping $\omega : U \rightarrow V$ by $\omega(u_1) = v_1, \omega(u_2) = v_2$ and $\psi : E \rightarrow K$ by $\psi(e_1) = k_1, \psi(e_2) = k_2$ then the mapping $\omega_\psi : (U, \tau, E) \rightarrow (V, \tau', K)$ is IF soft contra

gb-continuous mapping, but not an IF soft contra b-continuous map, since for the IF soft open set $(G_1, K) = \{G_1(k_1) = \{(v_1, .6, .3); (v_2, .5, .4), G_1(k_2) = \{(v_1, .4, .3); (v_2, .7, .1)\}$, $\omega_\psi^{-1}(G_1, K)$ not an IF soft b-closed set in (U, τ, E)

Theorem 3.6: Let (U, τ, E) and (V, τ', K) be any two IF soft topological spaces over U and V respectively. Let $\omega_\psi : (U, \tau, E) \rightarrow (V, \tau', K)$ be an IF soft mapping and $IFSGbO(U, \tau, E)$ is closed under arbitrary union. Then the following are equivalent

1. ω_ψ is an IF soft contra gb-continuous mapping
2. $(\omega_\psi)^{-1}(G, K)$ is an IF soft gb-open set in (U, τ, E) , for each IF soft closed set (G, K) in (V, τ', K) .
3. for each IF soft point e_F in (U, τ, E) and for each IF soft closed set $(G, K) \tilde{\in} \tau'$ with $\omega_\psi(e_F) \tilde{\in} (G, K)$, there exists an IF soft gb-open set (F, E) of (U, τ, E) containing e_F such that $\omega_\psi(F, E) \tilde{\subseteq} (G, K)$.

Proof:

(i) \Rightarrow (ii)

Let ω_ψ is an IF soft contra gb-continuous mapping and (G, K) be any IF soft closed set in (V, τ', K) . Then $(G, K)^c$ is an IF soft open set in (V, τ', K) . Therefore, by assumption, $(\omega_\psi)^{-1}(G, K)^c$ is an IF soft gb-closed set in (U, τ, E) . That is $((\omega_\psi)^{-1}(G, K))^c$ is IF soft gb-closed set in (U, τ, E) . Hence $(\omega_\psi)^{-1}(G, K)$ is an IF soft gb-open set in (U, τ, E) .

(ii) \rightarrow (i)

Let (G, K) be an IF soft open set in (V, τ', K) Then $(G, K)^c$ is an IF soft closed set in (V, τ', K) Therefore by assumption $(\omega_\psi)^{-1}(G, K)^c = ((\omega_\psi)^{-1}(G, K))^c$ is IF soft gb-open in (U, τ, E) . That is $(\omega_\psi)^{-1}(G, K)$ is IF soft gb-closed in (U, τ, E) . Hence ω_ψ is an IF soft contra gb-continuous mapping.

(ii) \rightarrow (iii)

Let e_F be an IF soft point of (U, τ, E) and (G, K) be an IF soft closed set in (V, τ', K) with $\omega_\psi(e_F) \tilde{\in} (G, K)$. Put $(F, E) = (\omega_\psi)^{-1}(G, K)$. Then by hypothesis, (F, E) is an IF soft gb-open set in (U, τ, E) such that $e_F \tilde{\in} (F, E)$ and $\omega_\psi(F, E) = \omega_\psi((\omega_\psi)^{-1}(G, K)) \tilde{\subseteq} (G, K)$.

(iii) \rightarrow (ii)

Let (G, K) be an IF soft closed set in (V, τ', K) and $e_F \tilde{\in} (\omega_\psi)^{-1}(G, K)$. Therefore $\omega_\psi(e_F) \tilde{\in} (G, K)$ and by assumption, there exists an IF soft gb-open set (F, E) of

(U, τ, E) such that $e_F \tilde{\in} (F_{ef}, E)$ and $\omega_\psi (F_{ef}, E) \tilde{\subseteq} (G, K)$ Therefore $(\omega_\psi)^{-1}(G, K) = \tilde{\cup} \{ (F_{ef}, E), e_F \tilde{\in} (\omega_\psi)^{-1}(G, K) \}$ and $(\omega_\psi)^{-1}(G, K)$ is IF soft gb-open in (U, τ, E) .

Theorem 3.7: Let (U, τ, E) and (V, τ', K) be any two IF soft topological spaces over U and V respectively. Let $\omega_\psi : (U, \tau, E) \rightarrow (V, \tau', K)$ be an IF soft function, Then

1. If ω_ψ is IF soft gb-continuous and (U, τ, E) is IF soft gb-locally indiscrete, then ω_ψ is IF soft contra continuous.
2. If ω_ψ is IF soft gb-irresolute and (U, τ, E) is IF soft gb-locally indiscrete, then ω_ψ is IF soft contra continuous.
3. If ω_ψ is IF soft contra gb-continuous and is IF soft gb-space, then ω_ψ is IF soft contra continuous.
4. If ω_ψ is IF soft contra gb-continuous and (U, τ, E) is IF soft T_{gb} -space, then ω_ψ is IF soft contra b-continuous...

proof: (i) Let ω_ψ an IF soft gb-continuous mapping and (G, K) be any IF soft open set in (V, τ', K) . Therefore, by assumption, $(\omega_\psi)^{-1}(G, K)$ is an IF soft gb-open set in (U, τ, E) . Since (U, τ, E) IF soft gb-locally indiscrete, $(\omega_\psi)^{-1}(G, K)$ is IF soft closed set in (U, τ, E) . Hence ω_ψ is an IF soft contra continuous function.

(ii) Let ω_ψ is an IF soft gb-irresolute mapping and (G, K) be any IF soft open set in (V, τ', K) . But every IF soft open set is IF soft gb-open. Therefore, by assumption, $(\omega_\psi)^{-1}(G, K)$ is an IF soft gb-open set in (U, τ, E) . Since (U, τ, E) is IF soft gb-locally indiscrete, $(\omega_\psi)^{-1}(G, K)$ is IF soft closed set in (U, τ, E) . Hence ω_ψ is an IF soft contra continuous function.

(iii) Let ω_ψ is an IF soft contra gb-continuous mapping and (G, K) be any IF soft open set in (V, τ', K) . Therefore $(\omega_\psi)^{-1}(G, K)$ is an IF soft gb-closed set in (U, τ, E) . Since (U, τ, E) is IF soft gb-space, $(\omega_\psi)^{-1}(G, K)$ is an IF soft closed set in (U, τ, E) . Hence ω_ψ is an IF soft contra continuous function.

(iv) Let ω_ψ is an IF soft contra gb-continuous mapping and (G, K) be any IF soft open set in (V, τ', K) . Therefore $(\omega_\psi)^{-1}(G, K)$ is an IF soft gb-closed set in (U, τ, E) . Since (U, τ, E) is IF soft T_{gb} -space, $(\omega_\psi)^{-1}(G, K)$ is an IF soft b-closed set in (U, τ, E) . Hence ω_ψ is an IF soft contra b-continuous function.

Theorem 3.8: Let $(U, \tau, E), (V, \tau', K)$ and (W, τ'', H) be IF soft topological spaces over U, V and W respectively and let $\omega_\psi : (U, \tau, E) \rightarrow (V, \tau', K)$ and $\xi_n : (V, \tau', K) \rightarrow (W, \tau'', H)$ be two IF soft functions.

- (i) If ω_ψ is IF soft contra gb-continuous and ξ_n is IF soft continuous, then $\xi_n \circ \omega_\psi : (U, \tau, E) \rightarrow (W, \tau'', H)$ is an IF soft contra gb-continuous function.
- (ii) If ω_ψ is IF soft gb-irresolute and ξ_n is IF soft contra gb-continuous, then $\xi_n \circ \omega_\psi : (U, \tau, E) \rightarrow (W, \tau'', H)$ is an IF soft contra gb-continuous function.
- (iii) If ω_ψ is IF soft gb-irresolute and ξ_n is IF soft contra continuous, then $\xi_n \circ \omega_\psi : (U, \tau, E) \rightarrow (W, \tau'', H)$ is an IF soft contra gb-continuous function.

Proof: (i) Let (M, H) be an IF soft open set in (W, τ'', H) . Then $\xi_n^{-1}(M, H)$ is IF soft open set in (V, τ', K) since ξ_n is IF soft continuous and also since ω_ψ is IF soft contra gb-continuous,

$(\omega_\psi)^{-1} ((\xi_n)^{-1}(M, H)) = (\xi_n \circ \omega_\psi)^{-1}(M, H)$ is IF soft gb-closed set in (U, τ, E) which implies

$(\xi_n \circ \omega_\psi)$ is an IF soft contra gb- continuous function.

(ii) Let (M, H) be an IF soft open set in (W, τ'', H) . Then $(\xi_n)^{-1}(M, H)$ is IF soft gb-closed set in (V, τ', K) since ξ_n is IF soft contra gb-continuous. Also, since ω_ψ is IF soft gb-irresolute,

$(\omega_\psi)^{-1} ((\xi_n)^{-1}(M, H)) = (\xi_n \circ \omega_\psi)^{-1}(M, H)$ is IF soft gb-closed set in (U, τ, E) and hence

$(\xi_n \circ \omega_\psi)$ is an IF soft contra gb- continuous function.

(iii) Let (M, H) be an IF soft open set in (W, τ'', H) . Then $(\xi_n)^{-1}(M, H)$ is IF soft closed set in (V, τ', K) , since ξ_n is IF soft contra gb-continuous. But every IF soft closed set is IF soft

gb-closed and hence $(\xi_n)^{-1}(M, H)$ is an IF soft gb-closed set in (V, τ', K) . Also since ω_ψ is IF soft gb-irresolute, $(\omega_\psi)^{-1} ((\xi_n)^{-1}(M, H)) = (\xi_n \circ \omega_\psi)^{-1}(M, H)$ is IF soft gb-closed set in (U, τ, E) and hence $(\xi_n \circ \omega_\psi)$ is an IF soft contra gb- continuous function.

4. IF SOFT ALMOST GB-CONTINUOUS FUNCTION

Definition 4.1: Let (U, τ, E) and (V, τ', K) be any two IF soft topological spaces over U and V respectively. An IF soft function $\omega_\psi : (U, \tau, E) \rightarrow (V, \tau', K)$ is said to be an

(i) IF soft almost continuous function if $(\omega_\psi)^{-1}(G, K)$ is an IF soft closed set in (U, τ, E) for every IF soft regular closed set (G, K) in (V, τ', K) .

(ii) IF soft almost gb-continuous function if $(\omega_\psi)^{-1}(G, K)$ is an IF soft gb-closed set in (U, τ, E) for every IF soft regular closed set (G, K) in (V, τ', K) .

(iii) IF soft almost R-function if $(\omega_\psi)^{-1}(G, K)$ is an IF soft regular closed set in (U, τ, E) for every IF soft regular closed set (G, K) in (V, τ', K) .

Theorem 4.2: (i) Every IF soft gb-continuous function is IF soft almost gb-continuous function.

(ii) Every IF soft continuous function is IF soft almost gb-continuous function.

(iii) Every IF soft gb-irresolute function is IF soft almost gb-continuous function.

(iv) Every IF soft almost continuous function is IF soft almost gb-continuous function.

Theorem 4.3: Let (U, τ, E) and (V, τ', K) be any two IF soft topological spaces over U and V respectively and $\omega_\psi : (U, \tau, E) \rightarrow (V, \tau', K)$ be an IF soft almost gb-continuous function and

(i) If (U, τ, E) is an IF soft gb-space, then ω_ψ is IF soft almost continuous function.

(ii) If (V, τ', K) is an IF soft semi-regular space, then ω_ψ is IF soft gb-continuous function.

(iii) If (V, τ', K) is an IF soft semi-gb space, then ω_ψ is IF soft gb-irresolute function.

Proof: (i) Let (G, K) be any IF soft regular closed set in (V, τ', K) . So, by assumption $(\omega_\psi)^{-1}(G, K)$ is IF soft gb-closed (U, τ, E) in . Since (U, τ, E) is an IF soft gb-space, $(\omega_\psi)^{-1}(G, K)$ is IF soft closed in (U, τ, E) . Therefore ω_ψ is IF soft almost continuous function.

(ii) Let (G, K) be any IF soft closed set in (V, τ', K) and (V, τ', K) be an IF soft semi-regular space. So, by assumption (G, K) is an IF soft regular closed set in (V, τ', K) and hence $(\omega_\psi)^{-1}(G, K)$ is IF soft gb-closed in (U, τ, E) . Therefore ω_ψ is IF soft gb-continuous function.

(iii) Let (G, K) be any IF soft gb-closed set in an IF soft semi-gb space (V, τ', K) So, by assumption (G, K) is an IF soft regular closed set in (V, τ', K) and hence $(\omega_\psi)^{-1}(G, K)$ is IF soft gb-closed in (U, τ, E) Therefore ω_ψ is IF soft gb-irresolute function.

Theorem 4.4: Let (U, τ, E) and (V, τ', K) be any two IF soft topological spaces over U and V respectively. Then an IF soft function $\omega_\psi : (U, \tau, E) \rightarrow (V, \tau', K)$ is an IF soft almost continuous function if and only if the inverse image of each IF soft regular open set over V is IF soft open in (U, τ, E) .

Proof: Let $\omega_\psi : (U, \tau, E) \rightarrow (V, \tau', K)$ be an IF soft almost continuous function and (G, K) be any IF soft regular open set in (V, τ', K) . Then $(G, K)^c$ is an IF soft regular closed set in (V, τ', K) . Therefore, by assumption $(\omega_\psi)^{-1}(G, K)^c$ is IF soft closed in (U, τ, E) . That is $((\omega_\psi)^{-1}(G, K))^c$ is IF soft closed in (U, τ, E) and hence $(\omega_\psi)^{-1}(G, K)$ is IF soft open in (U, τ, E) .

Conversely, let (G, K) be any IF soft regular closed set in (V, τ', K) . Then $(G, K)^c$ is an IF soft regular open set in (V, τ', K) and hence by hypothesis $(\omega_\psi)^{-1}(G, K)^c = ((\omega_\psi)^{-1}(G, K))^c$ is IF soft open in (U, τ, E) . Therefore $(\omega_\psi)^{-1}(G, K)$ is IF soft closed in (U, τ, E) and consequently ω_ψ is IF soft almost continuous.

Theorem 4.5: Let (U, τ, E) and (V, τ', K) be any two IF soft topological spaces over U and V respectively. Let $\omega_\psi : (U, \tau, E) \rightarrow (V, \tau', K)$ be an IF soft function. Then the following conditions are equivalent

- (i) ω_ψ is an IF soft almost gb-continuous function.
- (ii) $(\omega_\psi)^{-1}(G, K)$ is an IF soft gb-open set in (U, τ, E) , for each IF soft regular open set (G, K) in (V, τ', K) .
- (iii) $(\omega_\psi)^{-1}(int(cl(G, K)))$ is an IF soft gb-open set in (U, τ, E) , for each IF soft open set (G, K) in (V, τ', K) .
- (iv) $(\omega_\psi)^{-1}(cl(int(G, K)))$ is an IF soft gb-closed set in (U, τ, E) , for each IF soft closed set (G, K) in (V, τ', K) .

Proof:

(i) \rightarrow (ii)

Let ω_ψ is an IF soft almost gb-continuous mapping and (G, K) be any IF soft regular open set in (V, τ', K) . Then $(G, K)^c$ is an IF soft regular closed set in (V, τ', K) . Therefore, by assumption, $(\omega_\psi)^{-1}(G, K)^c$ is an IF soft gb-closed set in (U, τ, E) . That is $((\omega_\psi)^{-1}(G, K))^c$ is IF soft gb-closed set in (U, τ, E) . Hence $(\omega_\psi)^{-1}(G, K)$ is an IF soft gb-open set in (U, τ, E) .

(ii) \rightarrow (i)

Let (G, K) be an IF soft regular closed set in (V, τ', K) . Then $(G, K)^c$ is an IF soft regular open set in (V, τ', K) . Therefore, by assumption $(\omega_\psi)^{-1}(G, K)^c = ((\omega_\psi)^{-1}(G, K))^c$ is IF soft gb-open in (U, τ, E) . That is $(\omega_\psi)^{-1}(G, K)$ is IF soft gb-closed in (U, τ, E) . Hence ω_ψ is an IF soft almost gb-continuous mapping.

(ii) \Rightarrow (iii)

Let (G, K) be any IF soft open set in (V, τ', K) . Then $\text{int}(cl(G, K))$ is an IF soft regular open set in (V, τ', K) . Therefore, by assumption $(\omega_\psi)^{-1} \text{int}(cl(G, K))$ is IF soft gb-open in (U, τ, E) .

(iii) \Rightarrow (ii)

Let (G, K) be any IF soft regular open set in (V, τ', K) . Since every IF soft regular open set is IF soft open, (G, K) is IF soft open and hence by assumption, $(\omega_\psi)^{-1} \text{int}(cl(G, K)) = (\omega_\psi)^{-1}(G, K)$ is IF soft gb-open in (U, τ, E) .

(iii) \Rightarrow (iv)

Let (G, K) be any IF soft closed set in (V, τ', K) . Then $(G, K)^c$ is an IF soft open set in (V, τ', K) . Therefore, by assumption $(\omega_\psi)^{-1} \text{int}(cl((G, K)^c)) = (\omega_\psi)^{-1}(cl(\text{int}(G, K)))^c = [(\omega_\psi)^{-1} cl(\text{int}(G, K))]^c$ is IF soft gb-open in (U, τ, E) . Therefore $(\omega_\psi)^{-1} cl(\text{int}(G, K))$ is IF soft gb-closed in (U, τ, E) .

(iii) \Rightarrow (iv)

Let (G, K) be any IF soft open set in (V, τ', K) . Then $(G, K)^c$ is an IF soft closed set in (V, τ', K) . Therefore, by assumption $(\omega_\psi)^{-1} (cl(\text{int}(G, K)^c)) = (\omega_\psi)^{-1} (\text{int}(cl(G, K)))^c = [(\omega_\psi)^{-1} \text{int}(cl(G, K))]^c$ is IF soft gb-closed in (U, τ, E) . Therefore $(\omega_\psi)^{-1} (\text{int}(cl(G, K)))$ is IF soft gb-open in (U, τ, E) .

Theorem 4.6: Every IF soft R-map is IF soft almost gb-continuous.

Proof: Let (U, τ, E) and (V, τ', K) be any two IF soft topological spaces over U and V respectively. Let $\omega_\psi : (U, \tau, E) \rightarrow (V, \tau', K)$ be an IF soft R-function and (G, K) be any IF soft regular closed set in (V, τ', K) . Therefore, by assumption $(\omega_\psi)^{-1}(G, K)$ is IF soft regular closed set in (U, τ, E) . But every IF soft regular closed set is IF soft gb-closed, $(\omega_\psi)^{-1}(G, K)$ is IF soft gb-closed in (U, τ, E) and hence ω_ψ is IF soft almost gb-continuous.

Theorem 4.7: Let (U, τ, E) and (V, τ', K) be any two IF soft topological spaces over U and V respectively. Let $\omega_\psi : (U, \tau, E) \rightarrow (V, \tau', K)$ be an IF soft function and if $\text{IFSGBCS}(U, \tau, E)$ is closed under arbitrary intersection. Then the following conditions are equivalent

(i) ω_ψ is an IF soft almost gb-continuous function.

(ii) For each IF soft point e_F in (U, τ, E) and for each IF soft regular open set $(G, K) \tilde{\subseteq} (V, \tau', K)$ with $\omega_\psi(e_F) \tilde{\in} (G, K)$, there exists an IF soft gb-open set (F, E) of (U, τ, E) containing e_F such that $\omega_\psi(F, E) \tilde{\subseteq} (G, K)$.

(iii) For each IF soft point e_F in (U, τ, E) and for each IF soft neighborhood (G, K) of $\omega_\psi(e_F)$ there exists an IF soft gb-neighborhood (F, E) of e_F such that $\omega_\psi(F, E) \tilde{\subseteq} \text{int}(cl(G, K))$.

(iv) $\omega_\psi^{-1}(G, K) \subseteq gb \text{ int}(\omega_\psi^{-1}(\text{int}(cl(G, K))))$ for each IF soft open set (G, K) in (V, τ', K) .

(v) For each IF soft closed set (G, K) in (V, τ', K) $gbcl(\omega_\psi^{-1}(cl(\text{int}(G, K)))) \subseteq \omega_\psi^{-1}((G, K))$.

Proof: (i) \Rightarrow (ii)

Let (G, K) be an IF soft regular open set in (V, τ', K) and $e_F \in (\omega_\psi)^{-1}(G, K)$. Then $(G, K)^c$ is an IF soft regular closed set in (V, τ', K) and therefore by assumption, $(\omega_\psi)^{-1}(G, K)^c = ((\omega_\psi)^{-1}(G, K))^c$ is IF soft gb-closed set in (U, τ, E) . That is $(\omega_\psi)^{-1}(G, K)$ is IF soft gb-open set in (U, τ, E) . Take $e_F \in (\omega_\psi)^{-1}(G, K) = (F, E)$. Therefore (F, E) is an IF soft gb-open set such that $\omega_\psi(F, E) = \omega_\psi((\omega_\psi)^{-1}(G, K)) \subseteq (G, K)$.

(ii) \Rightarrow (iii)

Let e_F be an IF soft point in (U, τ, E) and let (G, K) be an IF soft neighborhood of $\omega_\psi(e_F)$ in (V, τ', K) . Therefore, by definition, there exists an IF soft open set (H, K) such that $\omega_\psi(e_F) \in (H, K) \subseteq (G, K)$. Since (H, K) is IF soft open $\text{int}(cl(H, K))$ is IF soft regular open set containing in $\omega_\psi(e_F)$ and hence, by hypothesis, there exists an IF soft gb-open set (F, E) containing e_F such that $\omega_\psi(F, E) \subseteq \text{int}(cl(H, K)) \subseteq \text{int}(cl(G, K))$. Therefore $\omega_\psi(F, E) \subseteq \text{int}(cl(G, K))$.

(iii) \Rightarrow (ii)

Let e_F be an IF soft point in (U, τ, E) and let (G, K) be an IF soft regular open set in (V, τ', K) containing $\omega_\psi(e_F)$. Since every IF soft regular open set is IF soft open, (G, K) is an IF soft neighborhood of $\omega_\psi(e_F)$ in (V, τ', K) . So, by assumption, there exists an IF soft

gb-neighborhood (H, E) of e_F in (U, τ, E) such that $\omega_\psi(H, E) \subseteq \text{int}(cl(G, K)) = (G, K)$. Since (H, E) is an IF soft gb-neighborhood of e_F , there exists an IF soft gb-open set (F, E) such that $e_F(F, E) \subseteq (H, E)$. Therefore $\omega_F(F, E) \subseteq \omega_\psi(H, E)$. Hence e_F belongs to the IF soft

gb-open set (F, E) such that $\omega_\psi(F, E) \subseteq (G, K)$.

(ii) \Rightarrow (iv)

Let e_F be an IF soft point in (U, τ, E) and $e_F \in (\omega_\psi)^{-1}(G, K)$, where (G, K) is an IF soft open set in (V, τ', K) . Then $\text{int}(cl(G, K))$ is an IF soft regular open set containing $\omega_\psi(e_F)$, since (G, K) is open. Therefore, there exists an IF soft gb-open set (F, E) containing e_F such that $\omega_\omega(F, E) \subseteq \text{int}(cl(G, K))$. Thus $e_F \in (F, E) \subseteq (\omega_\psi)^{-1}(\text{int}(cl(G, K)))$. That is $e_F \in gb - \text{int}[(\omega_\psi)^{-1}(\text{int}(cl(G, K)))]$ since (F, E) is IF soft gb-open. Thus $(\omega_\psi)^{-1}(G, K) \subseteq gb - \text{int}[(\omega_\psi)^{-1}(\text{int}(cl(G, K)))]$.

(iv) \Rightarrow (v)

Let (G, K) be any IF soft closed set in (V, τ', K) . Then $(G, K)^c$ is an IF soft open set in (V, τ', K) . Therefore, by assumption, $(\omega_\psi)^{-1}(G, K)^c \subseteq gb - \text{int}[(\omega_\psi)^{-1}(\text{int}(cl(G, K)^c))] \subseteq gb - \text{int}[(\omega_\psi)^{-1}(cl(\text{int}(G, K)))^c] \subseteq gb - \text{int}[(\omega_\psi)^{-1}(cl(\text{int}(G, K)))]^c \subseteq (gb - cl[(\omega_\psi)^{-1}(cl(\text{int}(G, K)))]^c)$

Therefore $gb - cl[(\omega_\psi)^{-1}(cl(\text{int}(G, K)))] \subseteq (\omega_\psi)^{-1}(G, K)$

(v) \Rightarrow (i)

Let (G, K) be any IF soft regular closed set in (V, τ', K) . Since every IF soft regular closed set is IF soft closed, by hypothesis, $gb - cl[(\omega_\psi)^{-1}(cl(int(G, K)))] \subseteq (\omega_\psi)^{-1}(G, K)$

. That is $gb - cl[(\omega_\psi)^{-1}(G, K)] \subseteq (\omega_\psi)^{-1}(G, K)$, since (G, K) is IF soft regular closed. Hence $(\omega_\psi)^{-1}(G, K)$ is IF soft gb-closed. Therefore ω_ψ is IF soft almost gb-continuous.

Theorem 4.8: Let $(U, \tau, E), (V, \tau', K)$ and (W, τ'', H) be IF soft topological spaces over U, V and W respectively and let $\omega_\psi : (U, \tau, E) \rightarrow (V, \tau', K)$ and $\xi_n : (V, \tau', K) \rightarrow (W, \tau'', H)$ be two IF soft functions and also $\xi_n \circ \omega_\psi : (U, \tau, E) \rightarrow (W, \tau'', H)$ be the IF soft composition mapping, then the following hold:

(i) If ω_ψ is IF soft gb-open and surjective and $\xi_n \circ \omega_\psi$ is IF soft almost continuous, then ξ_n is IF soft almost gb-continuous

(ii) If ω_ψ is IF soft gb-continuous and ξ_n is IF soft almost continuous, then $\xi_n \circ \omega_\psi$ is IF soft almost gb-continuous

Proof: (i) Let ω_ψ be an IF soft gb-open and surjective function, $\xi_n \circ \omega_\psi$ is IF soft almost continuous and (G, H) be an IF soft regular open set in (W, τ'', H) . Therefore, $(\xi_n \circ \omega_\psi)^{-1}(G, H) = (\omega_\psi)^{-1}((\xi_n)^{-1}(G, H))$ is IF soft open in (U, τ, E) . Since ω_ψ is IF soft gb-open and surjective, $\omega_\psi((\omega_\psi)^{-1}((\xi_n)^{-1}(G, H))) = (\xi_n)^{-1}(G, H)$ is IF soft gb-open in (V, τ', K) . Therefore ξ_n is IF soft almost gb-continuous.

(ii) Let ω_ψ be an IF soft gb-continuous, ξ_n is IF soft almost continuous and (G, H) be an IF soft regular open set in (W, τ'', H) . Therefore, by assumption, $(\xi_n)^{-1}(G, H)$ is IF soft open in (V, τ', K) . Since ω_ψ is IF soft gb-continuous, $(\omega_\psi)^{-1}((\xi_n)^{-1}(G, H)) = (\omega_\psi \circ \xi_n)^{-1}(G, H)$ is IF soft gb-open in (U, τ, E) . Therefore $\xi_n \circ \omega_\psi$ is IF soft almost gb-continuous.

5. CONCLUSION

The purpose of this paper is to introduce intuitionistic fuzzy soft contra gb-continuous function in intuitionistic fuzzy soft topological space and obtain several basic properties. Also, intuitionistic fuzzy soft almost generalized b-continuous function in intuitionistic fuzzy soft topological spaces are introduced and some of their properties are investigated.

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