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ON INTUITIONISTIC FUZZY ALMOST REGULAR GENERALIZED SEMI CONTINUOUS MAPPINGS

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ABSTRACT

In this paper, we introduce the concept of intuitionistic fuzzy almost regular generalized semi continuous mapping in intuitionistic fuzzy topological spaces and investigate some of their properties..

I. INTRODUCTION

Atanassov [4] introduced the idea of intuitionistic fuzzy sets using the notion of fuzzy sets. In 1997 Coker [5] introduced intuitionistic fuzzy topological spaces using the notion of intuitionistic fuzzy sets. The intuitionistic fuzzy regular generalized semi continuous mappings are introduced by Anitha, R., and Jayanthi, D [3]. In this paper we introduce intuitionistic fuzzy almost regular generalized semi continuous mappings in intuitionistic fuzzy topological spaces and we obtain some important theorems.

II. PRELIMINARIES

Definition 2.1:[4] An intuitionistic fuzzy set (IFS in short) A in X is an object having the form $A = \{\langle x, \mu_A(x), \nu_A(x)\rangle / x \in X\}$ where the function $\mu_A : X \to [0,1]$ and $\nu_A : X \to [0,1]$ denote the degree of membership (namely $\mu_A(x)$) and the degree of non-membership (namely $\nu_A(x)$) of each element $x \in X$ to the set A, respectively, and $0 \leq \mu_A(x) + \nu_A(x) \leq 1$ for each $x \in X$.

Definition 2.2: [4] Let A and B be two IFSs of the form $A = \{\langle x, \mu_A(x), \nu_A(x)\rangle / x \in X\}$ and $B = \{\langle x, \mu_B(x), \nu_B(x)\rangle / x \in X\}$. Then

a) $A \subseteq B$ if and only if $\mu_A(x) \leq \mu_B(x)$ and $\nu_A(x) \geq \nu_B(x)$ for all $x \in X$
b) $A = B$ if and only if $A \subseteq B$ and $B \subseteq A$
c) $A^c = \{\langle x, \nu_A(x), \mu_A(x)\rangle / x \in X\}$
d) $A \cap B = \{\langle x, \mu_A(x) \wedge \mu_B(x), \nu_A(x) \vee \nu_B(x)\rangle / x \in X\}$
e) $A \cup B = \{\langle x, \mu_A(x) \vee \mu_B(x), \nu_A(x) \wedge \nu_B(x)\rangle / x \in X\}$

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For the sake of simplicity, we shall use the notation $A = \langle x, \mu_A, \nu_A \rangle$ instead of $A = \{\langle x, \mu_A(x), \nu_A(x)\rangle / x \in X\}$. The IFS $0\sim = \{\langle x, 0, 1\rangle / x \in X\}$ and $1\sim = \{\langle x, 1, 0\rangle / x \in X\}$ are respectively the empty set and the whole set of X.

Definition 2.3: [5] An intuitionistic fuzzy topology (IFT in short) on X is a family τ of IFS 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 family $\{ G_i / i \in J\} \subseteq \tau$

In this case the pair (X,τ) is called an intuitionistic fuzzy topological space (IFTS in short) and any IFS in τ is known as an intuitionistic fuzzy open set (IFOS in short) in X. The complement A^c of an IFOS A in (X,τ) is called an intuitionistic fuzzy closed set (IFCS in short) in X.

Definition 2.4: [5] Let (X,τ) be an IFTS and $A = \langle x, \mu_A, \nu_A\rangle$ be an IFS in X. Then the intuitionistic fuzzy interior and intuitionistic fuzzy closure are defined by

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

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

Note that for any IFS A in (X,τ), we have $\text{cl}(A^c) = (\text{int}(A))^c$ and $\text{int}(A^c) = (\text{cl}(A))^c$

Definition 2.5: [7] An IFS $A = \langle x, \mu_A, \nu_A\rangle$ in an IFTS (X,τ) is said to be an
(i) intuitionistic fuzzy semi closed set (IFSCS in short) if $\text{int}(\text{cl}(A)) \subseteq A$
(ii) intuitionistic fuzzy α closed set (IFαCS in short) if $\text{cl}(\text{int}(\text{cl}(A))) \subseteq A$
(iii) intuitionistic fuzzy regular closed set (IFRCS in short) if $A = \text{cl}(\text{int}(A))$
(iv) intuitionistic fuzzy pre closed set (IFPCS in short) if $\text{cl}(\text{int}(A)) \subseteq A$
The respective complements of the above IFCSs are the respective IFOSs.

Definition 2.6: [1] An IFS A of an IFTS (X,τ) is said to be an intuitionistic fuzzy regular generalized semiclosed set (IFRGSCS in short) if $\text{scl}(A) \subseteq U$ whenever $A \subseteq U$ and U is an IFROS in X.
Definition 2.7: [2] An IFS A of an IFTS (X,τ) is said to be an intuitionistic fuzzy regular generalized semiopen set (IFRGSOS in short) if $\text{sint}(A) \supseteq U$ whenever $A \supseteq U$ and U is an IFRCS in X.

Note that the complement A^c of an IFRGSCS A in an IFTS (X,τ) is an IFRGSOS in (X,τ).

Corollary 2.8: [5] Let A, A_i $(i \in J)$ be intuitionistic fuzzy sets in X and B, B_j $(j \in K)$ be intuitionistic fuzzy sets in Y and $f : X \to Y$ be a function.
Then
a) $A_1 \subseteq A_2 \Rightarrow f(A_1) \subseteq f(A_2)$
b) $B_1 \subseteq B_2 \Rightarrow f^{-1}(B_1) \subseteq f^{-1}(B_2)$
c) $A \subseteq f^{-1}(f(A))$ [If f is injective , then $A=f^{-1}(f(A))$]

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d) $f(f^{-1}(B)) \subseteq B$ [If f is surjective , then $B=f(f^{-1}(B))$]
e) $f^{-1}(\cup B_j) = \cup f^{-1}(B_j)$
f) $f^{-1}(\cap B_j) = \cap f^{-1}(B_j)$
g) $f^{-1}(0\sim) = 0\sim$
h) $f^{-1}(1\sim) = 1\sim$
i) $f^{-1}(B^c) = (f^{-1}(B))^c$

Definition 2.9: [7] Let f be a mapping from an IFTS (X,τ) into an IFTS (Y,σ). Then f is said to be an intuitionistic fuzzy continuous (IF continuous in short) mapping if $f^{-1}(B) \in IFO(X)$ for every $B \in \sigma$.

Definition 2.10: [8] Let f be a mapping from an IFTS (X,τ) into an IFTS (Y,σ). Then f is said to be an
(i) intuitionistic fuzzy semi continuous (IFS continuous in short) mapping if $f^{-1}(B) \in IFSO(X)$ for every $B \in \sigma$
(ii) intuitionistic fuzzy α continuous (IFα continuous in short) mapping if $f^{-1}(B) \in IF\alpha O(X)$ for every $B \in \sigma$

Definition 2.11: [9] If every IFRGSCS in (X,τ) is an IFSCS in (X,τ), then the space can be called as an intuitionistic fuzzy regular semi $T_{1/2}$ space ($IF_{rs}T_{1/2}$ in short).

III. INTUITIONISTIC FUZZY ALMOST REGULAR GENERALIZED SEMI CONTINUOUS MAPPINGS

In this section we introduce the notion of intuitionistic fuzzy almost regular generalized semi continuous mapping and study some of their properties.

Definition 3.1: A mapping $f : X \to Y$ is said to be an intuitionistic fuzzy almost regular generalized semi continuous mapping (IFaRGS continuous mapping in short) if $f^{-1}(A)$ is an IFRGSCS in X for every IFRCS A in Y.

Example 3.2: Let X = {a,b}, Y = {u,v} and $G_1 = \langle x, (0.5, 0.6), (0.3, 0.3)\rangle$ where $\mu_a=0.5$, $\mu_b=0.6$, $\nu_a=0.3$, $\nu_b=0.3$ and $G_2 = \langle x, (0.3, 0.2), (0.7, 0.6)\rangle$ where $\mu_a=0.3$, $\mu_b=0.2$, $\nu_a=0.7$, $\nu_b=0.6$ and $G_3 = \langle y, (0.4, 0.3), (0.4, 0.5)\rangle$ where $\mu_u=0.4$, $\mu_v=0.3$, $\nu_u=0.4$, $\nu_v=0.5$. Then $\tau = \{0\sim, G_1, G_2, 1\sim\}$ and $\sigma = \{0\sim, G_3, 1\sim\}$ are IFTs on X and Y respectively. Define a mapping $f : (X,\tau) \to (Y,\sigma)$ by f(a) = u and f(b) = v. The IFS $G_3^c = \langle y, (0.4, 0.5), (0.4, 0.3)\rangle$ is an IFRCS in Y. Then $f^{-1}(G_3^c) = \langle x, (0.4, 0.5), (0.4, 0.3)\rangle$ where $\mu_a=0.4$, $\mu_b=0.5$, $\nu_a=0.4$, $\nu_b=0.3$ is an IFS in X. Then $f^{-1}(G_3^c) \subseteq G_1$ where G_1 is an IFROS in X. Now $scl(f^{-1}(G_3^c)) = G_1 \subseteq G_1$. Therefore $f^{-1}(G_3^c)$ is an IFRGSCS in X. Thus f is an IFaRGS continuous mapping.

Theorem 3.3: Every IF continuous mapping is an IFaRGS continuous mapping but not conversely.

Proof: Let $f : (X,\tau) \to (Y,\sigma)$ be an IF continuous mapping. Let V be an IFRCS in Y. Since every IFRCS is an IFCS, V is an IFCS in Y. Then $f^{-1}(V)$ is an IFCS in X, by hypothesis. Since every IFCS is an IFRGSCS [1], $f^{-1}(V)$ is an IFRGSCS in X. Hence f is an IFaRGS continuous mapping.

Example 3.4: Let X = {a,b}, Y = {u,v} and $G_1 = \langle x, (0.6,0.4), (0.4,0.2)\rangle$ $G_2 = \langle x, (0.1, 0.2), (0.8, 0.8)\rangle$, $G_3 = \langle y, (0.4, 0.3), (0.6, 0.3)\rangle$. Then $\tau = \{0\sim, G_1, G_2, 1\sim\}$ and $\sigma = \{0\sim, G_3, 1\sim\}$ are IFTs on X and Y respectively. Define a mapping $f : (X,\tau) \to (Y,\sigma)$ by f(a) = u and f(b) = v. The IFS $G_3^c = \langle y, (0.6, 0.3), (0.4, 0.3)\rangle$ is an IFRCS in Y. Then $f^{-1}(G_3^c) = \langle x, (0.6, 0.3), (0.4, 0.3)\rangle$ is an IFS in X. Then f

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$^{-1}(G_3^c) \subseteq G_1$ where G_1 is an IFROS in X. Now $scl(f^{-1}(G_3^c)) = G_1 \subseteq G_1$. Therefore $f^{-1}(G_3^c)$ is an IFRGSCS in X but not an IFCS in X, since $cl(f^{-1}(G_3^c)) = G_1^c \neq f^{-1}(G_3^c)$. Therefore f is an IFaRGS continuous mapping but not an IF continuous mapping.

Theorem 3.5: Every IFG continuous mapping is an IFaRGS continuous mapping but not conversely.

Proof: Let $f : (X,\tau) \rightarrow (Y,\sigma)$ be an IFG continuous mapping. Let V be an IFRCS in Y. Since every IFRCS is an IFCS, V is an IFCS in Y. Then $f^{-1}(V)$ is an IFGCS in X, by hypothesis. Since every IFGCS is an IFRGSCS [1], $f^{-1}(V)$ is an IFRGSCS in X. Hence f is an IFaRGS continuous mapping.

Example 3.6: Let X = {a,b}, Y = {u,v} and $G_1 = \langle x, (0.6, 0.5), (0.2, 0.4)\rangle$ $G_2 = \langle x, (0.2, 0.4), (0.8, 0.5)\rangle$, $G_3 = \langle y, (0.4, 0.4), (0.5, 0.4)\rangle$. Then $\tau = \{0\sim, G_1, G_2, 1\sim\}$ and $\sigma = \{0\sim, G_3, 1\sim\}$ are IFTs on X and Y respectively. Define a mapping $f : (X,\tau) \rightarrow (Y,\sigma)$ by f(a) = u and f(b) = v. The IFS $G_3^c = \langle y, (0.5, 0.4), (0.4, 0.4)\rangle$ is an IFRCS in Y. Then $f^{-1}(G_3^c) = \langle x, (0.5, 0.4), (0.4, 0.4)\rangle$ is an IFS in X. Then $f^{-1}(G_3^c) \subseteq G_1$ where G_1 is an IFROS in X. Now $scl(f^{-1}(G_3^c)) = G_1 \subseteq G_1$. Therefore $f^{-1}(G_3^c)$ is an IFRGSCS in X but not an IFGCS in X, since $cl(f^{-1}(G_3^c)) = G_2^c \nsubseteq G_1$. Therefore f is an IFaRGS continuous mapping but not an IFG continuous mapping.

Theorem 3.7: Every IFS continuous mapping is an IFaRGS continuous mapping but not conversely.

Proof: Let $f : (X,\tau) \rightarrow (Y,\sigma)$ be an IFS continuous mapping. Let V be an IFRCS in Y. Since every IFRCS is an IFCS, V is an IFCS in Y. Then $f^{-1}(V)$ is an IFSCS in X, by hypothesis. Since every IFSCS is an IFRGSCS [1], $f^{-1}(V)$ is an IFRGSCS in X. Hence f is an IFaRGS continuous mapping.

Example 3.8: Let X = {a,b}, Y = {u,v} and $G_1 = \langle x, (0.4, 0.5), (0.3, 0.2)\rangle$ $G_2 = \langle x, (0.2, 0.2), (0.8, 0.6)\rangle$, $G_3 = \langle y, (0.3, 0.4), (0.4, 0.4)\rangle$. Then $\tau = \{0\sim, G_1, G_2, 1\sim\}$ and $\sigma = \{0\sim, G_3, 1\sim\}$ are IFTs on X and Y respectively. Define a mapping $f : (X,\tau) \rightarrow (Y,\sigma)$ by f(a) = u and f(b) = v. The IFS $G_3^c = \langle y, (0.4, 0.4), (0.3, 0.4)\rangle$ is an IFRCS in Y. Then $f^{-1}(G_3^c) = \langle x, (0.4, 0.4), (0.3, 0.4)\rangle$ is an IFS in X. Then $f^{-1}(G_3^c) \subseteq G_1$ where G_1 is an IFROS in X. Now $scl(f^{-1}(G_3^c)) = G_1 \subseteq G_1$. Therefore $f^{-1}(G_3^c)$ is an IFRGSCS in X but not an IFSCS in X, since $int(cl(f^{-1}(G_3^c))) = G_1 \nsubseteq f^{-1}(G_3^c)$. Therefore f is an IFaRGS continuous mapping but not an IFS continuous mapping.

Theorem 3.9: Every IFα continuous mapping is an IFaRGS continuous mapping but not conversely.

Proof: Let $f : (X,\tau) \rightarrow (Y,\sigma)$ be an IFα continuous mapping. Let V be an IFRCS in Y. Since every IFRCS is an IFCS, V is an IFCS in Y. Then $f^{-1}(V)$ is an IFαCS in X, by hypothesis. Since every IFαCS is an IFRGSCS [1], $f^{-1}(V)$ is an IFRGSCS in X. Hence f is an IFaRGS continuous mapping.

Example 3.10: Let X = {a,b}, Y = {u,v} and $G_1 = \langle x, (0.5, 0.4), (0.3, 0.2)\rangle$ $G_2 = \langle x, (0.3, 0.2), (0.6, 0.5)\rangle$, $G_3 = \langle y, (0.4, 0.4), (0.5, 0.4)\rangle$. Then $\tau = \{0\sim, G_1, G_2, 1\sim\}$ and $\sigma = \{0\sim, G_3, 1\sim\}$ are IFTs on X and Y respectively. Define a mapping $f : (X,\tau) \rightarrow (Y,\sigma)$ by f(a) = u and f(b) = v. The IFS $G_3^c = \langle y, (0.5, 0.4), (0.4, 0.4)\rangle$ is an IFRCS in Y. Then $f^{-1}(G_3^c) = \langle x, (0.5, 0.4), (0.4, 0.4)\rangle$ is an IFS in X. Then $f^{-1}(G_3^c) \subseteq G_1$ where G_1 is an IFROS in X. Now $scl(f^{-1}(G_3^c)) = G_1 \subseteq G_1$. Therefore $f^{-1}(G_3^c)$ is an IFRGSCS in X but not an IFαCS in X, since $cl(int(cl(f^{-1}(G_3^c))) = G_2^c \nsubseteq f^{-1}(G_3^c)$. Therefore f is an IFaRGS continuous mapping but not an IFα continuous mapping.

Theorem 3.11: A mapping $f : X \rightarrow Y$ is an IFaRGS continuous mapping if and only if the inverse image of each IFROS in Y is an IFRGSOS in X.

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Proof: Necessity: Let A be an IFROS in Y. This implies A^c is an IFRCS in Y. Since f is an IFaRGS continuous mapping, $f^{-1}(A^c)$ is an IFRGSCS in X. Since $f^{-1}(A^c) = (f^{-1}(A))^c$, $f^{-1}(A)$ is an IFRGSOS in X.

Sufficiency: Let A be an IFRCS in Y. This implies A^c is an IFROS in Y. By hypothesis, $f^{-1}(A^c)$ is an IFRGSOS in X. Since $f^{-1}(A^c) = (f^{-1}(A))^c$, $f^{-1}(A)$ is an IFRGSCS in X. Hence f is an IFaRGS continuous mapping.

Theorem 3.12: Let $f : X \to Y$ be a mapping where $f^{-1}(V)$ is an IFRCS in X for every IFCS in Y. Then f is an IFaRGS continuous mapping but not conversely.

Proof: Let V be an IFRCS in Y. Since every IFRCS is an IFCS, V is an IFCS in Y. Then $f^{-1}(V)$ is an IFRCS in X. Since every IFRCS is an IFRGSCS [1], $f^{-1}(V)$ is an IFRGSCS in X. Hence f is an IFaRGS continuous mapping.

Example 3.13: Let X = {a,b}, Y = {u,v} and $G_1 = \langle x, (0.5, 0.6), (0.3, 0.4)$ $G_2 = \langle x, (0.3, 0.2), (0.6, 0.6)\rangle$, $G_3 = \langle y, (0.4, 0.4), (0.4, 0.5)\rangle$. Then $\tau = \{0\sim, G_1, G_2, 1\sim\}$ and $\sigma = \{0\sim, G_3, 1\sim\}$ are IFTs on X and Y respectively. Define a mapping $f : (X,\tau) \to (Y,\sigma)$ by f(a) = u and f(b) = v. The IFS $G_3^c = \langle y, (0.4, 0.5), (0.4, 0.4)\rangle$ is an IFRCS in Y. Then $f^{-1}(G_3^c) = \langle x, (0.4, 0.5), (0.4, 0.4)\rangle$ is an IFS in X. Then $f^{-1}(G_3^c) \subseteq G_1$ where G_1 is an IFROS in X. Now $scl(f^{-1}(G_3^c)) = G_1 \subseteq G_1$. Therefore $f^{-1}(G_3^c)$ is an IFRGSCS in X but not an IFRCS in X, since $cl(int(f^{-1}(G_3^c))) = G_2^c \neq f^{-1}(G_3^c)$. Therefore f is an IFaRGS continuous mapping, but not the mapping as in theorem 3.12.

Theorem 3.14: Let $f : X \to Y$ be a mapping. If $f^{-1}(sint(B)) \subseteq sint(f^{-1}(B))$ for every IFS B in Y, then f is an IFaRGS continuous mapping.

Proof: Let B be an IFROS in Y. By hypothesis, $f^{-1}(sint(B)) \subseteq sint(f^{-1}(B))$. Since B is an IFROS, it is an IFSOS in Y. Therefore sint(B) = B. Hence $f^{-1}(B) = f^{-1}(sint(B)) \subseteq sint(f^{-1}(B)) \subseteq f^{-1}(B)$. Therefore $f^{-1}(B) = sint(f^{-1}(B))$. This implies $f^{-1}(B)$ is an IFSOS in X and hence $f^{-1}(B)$ is an IFRGSOS[2] in X. Thus f is an IFaRGS continuous mapping.

Remark 3.15: The converse of the above theorem 3.14 is true if B is an IFROS in Y and X is an $IF_{rs}T_{1/2}$ space.

Proof: Let f be an IFaRGS continuous mapping. Let B be an IFROS in Y. Then $f^{-1}(B)$ is an IFRGSOS in X. Since X is an $IF_{rs}T_{1/2}$ space, $f^{-1}(B)$ is an IFSOS in X. This implies $f^{-1}(B) = sint(f^{-1}(B))$. Now $f^{-1}(sint(B)) \subseteq f^{-1}(B) = sint(f^{-1}(B))$. Therefore $f^{-1}(sint(B)) \subseteq sint(f^{-1}(B))$.

Theorem 3.16: Let $f : X \to Y$ be a mapping. If $scl(f^{-1}(B)) \subseteq f^{-1}(scl(B))$ for every IFS B in Y, then f is an IFaRGS continuous mapping.

Proof: Let B be an IFRCS in Y. By hypothesis, $scl(f^{-1}(B)) \subseteq f^{-1}(scl(B))$. Since B is an IFRCS, it is an IFSCS in Y. Therefore scl(B) = B. Hence $f^{-1}(B) = f^{-1}(scl(B)) \supseteq scl(f^{-1}(B)) \supseteq f^{-1}(B)$. Therefore $f^{-1}(B) = scl(f^{-1}(B))$. This implies $f^{-1}(B)$ is an IFSCS in X and hence $f^{-1}(B)$ is an IFRGSCS [1] in X. Thus f is an IFaRGS continuous mapping.

Remark 3.17: The converse of the above theorem 3.16 is true if B is an IFRCS in Y and X is an $IF_{rs}T_{1/2}$ space.

Proof: Let f be an IFaRGS continuous mapping. Let B be an IFRCS in Y. Then $f^{-1}(B)$ is an IFRGSCS in X. Since X is an $IF_{rs}T_{1/2}$ space, $f^{-1}(B)$ is an IFSCS in X. This implies $scl(f^{-1}(B)) = f^{-1}(B)$. Now $f^{-1}(scl(B)) \supseteq f^{-1}(B) = scl(f^{-1}(B))$. Therefore $f^{-1}(scl(B)) \supseteq scl(f^{-1}(B))$.

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Theorem 3.18: Let $f : X \rightarrow Y$ be a mapping where X is an $IF_{rs}T_{1/2}$ space. If f is an IFaRGS continuous mapping, then $int(cl(f^{-1}(B))) \subseteq f^{-1}(scl(B))$ for every IFRCS B in Y.

Proof: Let B be an IFRCS in Y. By hypothesis, $f^{-1}(B)$ is an IFRGSCS in X. Since X is an $IF_{rs}T_{1/2}$ space, $f^{-1}(B)$ is an IFSCS in X. This implies $scl(f^{-1}(B)) = f^{-1}(B)$. Now $int(cl(f^{-1}(B))) \subseteq f^{-1}(B) \cup int(cl(f^{-1}(B))) \subseteq scl(f^{-1}(B)) = f^{-1}(B) = f^{-1}(scl(B))$, as every IFRCS is an IFSCS. Hence $int(cl(f^{-1}(B))) \subseteq f^{-1}(scl(B))$.

Theorem 3.19: Let $f : X \rightarrow Y$ be a mapping where X is an $IF_{rs}T_{1/2}$ space. If f is an IFaRGS continuous mapping, then $f^{-1}(sint(B)) \subseteq cl(int(f^{-1}(B)))$ for every IFROS B in Y.

Proof: This theorem can be easily proved by taking complement in Theorem 3.18.

IV RESULTS AND DISCUSSION

In this paper we have discussed the concept of intuitionistic fuzzy almost regular generalized semi continuous mapping in intuitionistic fuzzy topological spaces and investigated some of their properties..

V CONCLUSION

Thus we have analyzed intuitionistic fuzzy almost regular generalized semi continuous mapping and obtained some interesting theorems.

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