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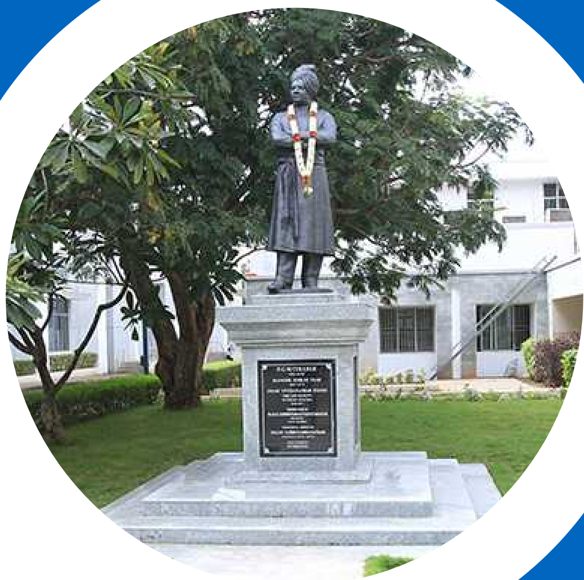

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Department of Biological Science, Physical Science and Computational Science

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ABOUT THE INSTITUTION

A nations's growth is in proportion to education and intelligence spread among the masses. Having this idealistic vision, two great philanthropists late. S.P. Nallamuthu Gounder and Late. Arutchelver Padmabhushan Dr.N.Mahalingam formed an organization called Pollachi Kalvi Kazhagam, which started NGM College in 1957, to impart holistic education with an objective to cater to the higher educational needs of those who wish to aspire for excellence in knowledge and values. The College has achieved greater academic distinctions with the introduction of autonomous system from the academic year 1987-88. The college has been Re-Accredited by NAAC and it is ISO 9001 : 2015 Certified Institution. The total student strength is around 6000. Having celebrated its Diamond Jubilee in 2017, the college has blossomed into a premier Post-Graduate and Research Institution, offering 26 UG, 12 PG, 13 M.Phil and 10 Ph.D Programmes, apart from Diploma and Certificate Courses. The college has been ranked within Top 100 (72nd Rank) in India by NIRF 2021.

ABOUT CONFERENCE

The International conference on “Emerging Trends in Science and Technology (ETIST-2021)” is being jointly organized by Departments of Biological Science, Physical Science and Computational Science - Nallamuthu Gounder Mahalingam College, Pollachi along with ISTE, CSI, IETE, IEE & RIYASA LABS on 27th OCT 2021. The Conference will provide common platform for faculties, research scholars, industrialists to exchange and discus the innovative ideas and will promote to work in interdisciplinary mode.

A NEW OPEN AND CLOSED MAPPING IN INTUITIONISTIC FUZZY TOPOLOGICAL SPACES

M. Rameshkumar[1] – R. Santhi[2]

ABSTRACT: In this paper we introduce a new open and closed mapping in intuitionistic fuzzy topological spaces and studied some of their properties. We also study the relationship between other existing mappings in intuitionistic fuzzy topological spaces.

Keywords: Intuitionistic fuzzy topology, Intuitionistic fuzzy g*-open mapping, Intuitionistic fuzzy g*-closed mapping.

1. INTRODUCTION

In 1965, Zadeh [14] introduced to the world the term fuzzy set (FS), as a formalization of vagueness and partial truth, and represents a degree of membership for each member of the universe of discourse to a subset of it. Later on Chang [2] introduced Fuzzy topology in 1968.

After two decades, in 1983, Atanassov [1] introduced the concept of intuitionistic fuzzy sets(IFS) as a generalization of fuzzy sets. In 1997 intuitionistic fuzzy open sets, intuitionistic fuzzy closed sets and intuitionistic fuzzy topological space was introduced by Coker [3]. After this many concepts in fuzzy topological spaces extended to intuitionistic fuzzy topological spaces.

In 1970, Levine [8] goes a step further and introduced g-closed, it is the generalization of closed sets in general topology. Whereas Veerakumar [12] in 2000, says that g*-closed sets is in between closed sets and g-closed sets in general topology. Rameshkumar [9] introduced g*-closed sets is in intuitionistic fuzzy topological spaces. In this paper we introduce g*-open and g*-closed mappings in intuitionistic fuzzy topological spaces and studied their properties.

2. PRELIMINARIES

Definition 2.1: [1] Let X be a non empty fixed set. 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 functions $\mu A(x): X \to [0,1]$ and $\nu A(x): X \to [0,1]$

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denote the degree of membership (namely μA(x)) and the degree of non-membership (namely νA(x)) of each element x ∈ X to the set A, respectively, and $0 \leq \mu A(x) + \nu A(x) \leq 1$ for each x ∈ X. Denote by IFS(X), the set of all intuitionistic fuzzy sets in X.

Definition 2.2: [1] Let A and B be IFSs of the form A = { ⟨ x, μA(x), νA(x) ⟩ / x ∈ X } and B = {⟨ x, μB(x), νB(x)⟩ / x ∈ X }. Then

(a) A ⊆ B if and only if μA(x) ≤ μB (x) and νA(x) ≥ νB(x) for all x ∈ X

(b) A = B if and only if A ⊆ B and B ⊆ A

(c) A^c = { ⟨ x, μA(x), νA(x) ⟩ / x ∈ X }

(d) A ∩ B = { ⟨ x, μA(x) ∧ μB(x), νA(x) ∨ νB(x) ⟩ / x ∈ X }

(e) A ∪ B = { ⟨ x, μA(x) ∨ μB(x), νA(x) ∧ νB(x) ⟩ / x ∈ X }

(f) 0~ = {⟨ x, 0, 1 ⟩ : x ∈ X } and 1~ = {⟨ x, 1, 0 ⟩ : x ∈ X }

(g) $1_{\sim}^{c} = 0_{\sim}$ and $0_{\sim}^{c} = 1_{\sim}$

For the sake of simplicity, we shall use the notation A = ⟨ x, μA, νA ⟩ instead of {⟨x, μA(x), νA(x) ⟩/ x ∈ X }.

Also for the sake of simplicity, we shall use the notation A = ⟨ x, (μA, μB),(νA, νB)⟩ instead of A = ⟨ x, (A/μA, B/μB), (A/νA, B/νB) ⟩.

Definition 2.3: [3] An intuitionistic fuzzy topology (IFT in short) on X is a family τ of IFSs in X satisfying the following axioms.

(i) $0_{\sim}, 1_{\sim} \in \tau$

(ii) $G_1 \cap G_2 \in \tau$, for any $G_1, G_2 \in \tau$

(iii) $\cup G_i \in \tau$ 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 Ac of an IFOS A in an IFTS (X, τ) is called an intuitionistic fuzzy closed set (IFCS in short) in X.

Definition 2.4: [3] Let (X, τ) be an IFTS and A = ⟨ x, μA, νA ⟩ be an IFS in X. Then the intuitionistic fuzzy interior and an intuitionistic fuzzy closure are defined by

int(A) = ∪ { G / G is an IFOS in X and G ⊆ A },

cl(A) = ∩ { K / K is an IFCS in X and A ⊆ K }.

Definition 2.5: An IFS A of an IFTS (X, τ) is an

(i) intuitionistic fuzzy pre closed set [7] (IFPCS in short) if cl(int(A)) ⊆ A,

(ii) intuitionistic fuzzy α-closed set [6] (IFαCS in short) if cl(int(cl(A)) ⊆ A.

(iii) intuitionistic fuzzy semi closed set [6] (IFSCS in short) if int(cl(A)) ⊆ A,

(iv) intuitionistic fuzzy regular closed set [6] (IFRCS in short) if A = cl(int(A)),

(v) intuitionistic fuzzy regular open set [6] (IFROS in short) if A ⊆ int(cl(A)).

Definition 2.6: [11] An IFS A of an IFTS (X, τ) is an intuitionistic fuzzy generalized closed set (IFGCS in short) if cl(A) ⊆ U whenever A ⊆ U and U is an IFOS in X.

Definition 2.7: [9] An IFS A in (X, τ) is said to be an intuitionistic fuzzy g*-closed set (IFG∗CS in short) if cl(A) ⊆ U whenever A ⊆ U and U is an IFGOS in (X, τ).

Definition 2.8: [6] An IFP x(α,β) is said to be an intuitionistic fuzzy θ-cluster point of an IFS U if and only if cl(A)qU for each q-neighborhood A of x(α,β).The set of all intuitionistic fuzzy θ-cluster points of U is called an intuitionistic fuzzy θ-closure of U and is denoted by $cl_\theta(U)$. An IFS U will be called an intuitionistic fuzzy θ-closed (IFθCS for short) if and only if U = $cl_\theta(U)$. The complement of an IFθCS is called an intuitionistic fuzzy θ-open set (IFθOS for short).

Definition 2.9: [9] An IFTS (X, τ) is said to be an intuitionistic fuzzy $T^*_{\frac{1}{2}}$ space (in short IF$T^*_{\frac{1}{2}}$) if every IFG∗CS of (X, τ) is an IFCS of (X, τ).

Definition 2.10: [10] A mapping f: (X, τ) → (Y, σ) is called an intuitionistic fuzzy g*-continuous (IFG∗ continuous in short) if $f^{-1}(B)$ is an IFG∗CS in (X, τ) for every IFCS B of (Y, σ).

Definition 2.11: [5] A map f: X → Y is called an

(i) intuitionistic fuzzy semi-open mapping (IFSOM for short) if f(A) is an IFSOS in Y for each IFOS A in X.

(ii) intuitionistic fuzzy α-open mapping (IFαOM for short) if f(A) is an IFαOS in Y for each IFOS A in X.

(iii) intuitionistic fuzzy preopen mapping (IFPOM for short) if f(A) is an IFPOS in Y foreach IFOS A in X.

Definition 2.12: [13] A mapping f: X→Y is called an intuitionistic fuzzy pre regular closed mapping (IFPRCM for short) if f(V) is an IFRCS in Y for every IFRCS V of X.

3. INTUITIONISTIC FUZZY g* CLOSED SETS FIGURES AND OTHER ILLUSTRATIONS

Definition 3.1: A mapping *f* : X → Y is said to be intuitionistic fuzzy g^*-open mapping (IFG∗OM) if *f* (A) is an IFG∗OS in Y, for every IFOS A in X.

Definition 3.2: A mapping *f* : X → Y is said to be intuitionistic fuzzy g^*-closed mapping (IFG∗CM) if *f* (A) is an IFG∗CS in Y, for every IFCS A in X.

Theorem 3.3: Every intuitionistic fuzzy open (resp. intuitionistic fuzzy closed) mapping is an intuitionistic fuzzy g^*-open (resp. intuitionistic fuzzy g^*-closed) mapping.

Proof: Obvious

Remark 3.4: Converse of the Theorem 3.3 need not be true as seen from the following example.

Example 3.5: Let X = {a, b} and Y = {u, v}. Let A = ⟨ x, (0.2, 0.2), (0.7, 0.8) ⟩ and B = ⟨ y, (0.5, 0.3), (0.7, 0.8) ⟩. Then τ = {$0_\sim$, A, $1_\sim$} and σ = {$0_\sim$, B, $1_\sim$} are an IFTs on X and Y respectively. Define a mapping *f* : (X, τ) → (Y, σ) by *f* (a) = u and *f* (b) = v. Then *f* is an IFG∗OM but not an IFOM.

Theorem 3.6: Every intuitionistic fuzzy g^*-open (resp. intuitionistic fuzzy g^*-closed) mapping is an intuitionistic fuzzy g-open (resp. intuitionistic fuzzy g-closed) mapping.

Proof: Let *f* : X → Y be an IFG∗OM. Let A be an IFOS in X. Then *f* (A) is an IFG∗OS in Y. Since every IFG∗OS is an IFGOS, *f* (A) is an IFGOS in Y. Hence *f* is an IFGOM.

Remark 3.7: Converse of the Theorem 3.6 need not be true as seen from the following example.

Example 3.8: Let X = {a, b} and Y = {u, v}. Let A = ⟨ x, (0.4, 0.2), (0.6, 0.6) ⟩ and B = ⟨ y, (0.5, 0.2), (0.4, 0.2) ⟩. Then $\tau = \{0_\sim, A, 1_\sim\}$ and $\sigma = \{0_\sim, B, 1_\sim\}$ are an 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 IFGOM but not an IFG∗OM.

Theorem 3.9: Every intuitionistic fuzzy g^*-open (resp. intuitionistic fuzzy g^*-closed) mapping is an intuitionistic fuzzy αg-open (resp. intuitionistic fuzzy αg-closed) mapping.

Proof: Let $f : X \to Y$ be an IFG∗OM. Let A be an IFOS in X. Then f (A) is an IFG∗OS in Y. Since every IFG∗OS is an IFαGOS, f (A) is an IFαGOS in Y. Hence f is an IFαGOM.

Remark 3.10: Converse of the Theorem 3.9 need not be true as seen from the following example.

Example 3.11: Let X = {a, b} and Y = {u, v}. Let A = ⟨ x, (0.1, 0.4), (0.6, 0.5) ⟩ and B = ⟨ y, (0.3, 0.4), (0.2, 0.5) ⟩. Then $\tau = \{0_\sim, A, 1_\sim\}$ and $\sigma = \{0_\sim, B, 1_\sim\}$ are an 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 IFαGOM but not an IFG∗OM.

Theorem 3.12: Every intuitionistic fuzzy θ-open (resp. intuitionistic fuzzy θ-closed) mapping is an intuitionistic fuzzy g^*-open (resp. intuitionistic fuzzy g^*-closed) mapping.

Proof: Let $f : X \to Y$ be an IFGθOM. Let A be an IFOS in X. Since f is an IFθOM, f (A) is an IFGθOS in Y. Since every IFθOS is an IFG∗OS, f (A) is an IFG∗OS in Y. Hence f is an IFG∗OM.

Remark 3.13: Converse of the Theorem 3.12 need not be true as seen from the following example.

Example 3.14: Let X = {a, b} and Y = {u, v, w}. Let A = ⟨ x, (0, 0, 0.5), (1, 1, 0) ⟩, B = ⟨ y, (1, 1, 0), (0, 0, 0.5) ⟩ and C = ⟨ y, (0, 0.5, 1), (1, 0.5, 0) ⟩. Then $\tau = \{0_\sim, A, 1_\sim\}$ and $\sigma = \{0_\sim, B, C, B \cup C, 1_\sim\}$ are an 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 IFG∗OM but not an IFθOM.

Remark 3.15: The relation between various types of intuitionistic fuzzy open mapping is given in the following diagram.

$$\begin{tikzcd}
\mathrm{IF\theta OM} \arrow[r] \arrow[d] & \mathrm{IFG{*}OM} \arrow[r] & \mathrm{IFGOM} \arrow[d] \\
\mathrm{IFOM} \arrow[ur] \arrow[r] & \mathrm{IF\alpha OM} \arrow[r] & \mathrm{IF\alpha GOM}
\end{tikzcd}$$

Theorem 3.16: Let $f : X \to Y$ be a mapping. Then the following are equivalent if Y is an IF$T^*_{\frac{1}{2}}$ space:

(i) f is an IFG∗CM.

(ii) $cl(f(A)) \subseteq f(cl(A))$ for each IFS A of X.

Proof: (i) ⇒ (ii) Let A be an IFS in X. Then cl(A) is an IFCS in X. By assumption f (cl(A)) is an IFG∗CS in Y. Since Y is an IF$T^*_{\frac{1}{2}}$ space, f (cl(A)) is an IFCS in Y. Therefore $cl(f(cl(A))) = f(cl(A))$. Now, $cl(f(A)) \subseteq cl(f(cl(A))) = f(cl(A))$. Hence $cl(f(A)) \subseteq f(cl(A))$ for each IFS A of X.

(ii) ⇒ (i) Let A be an IFCS in X. Then cl(A) = A. By assumption, $cl(f(A)) \subseteq f(cl(A)) = f(A)$. This implies f (A) is an IFCS in Y. Since every IFCS is an IFG∗CS, f (A) is an IFG∗CS in Y. Hence f is an IFG∗CM.

Theorem 3.17: Let f : X → Y be a bijection. Then the following are equivalent if Y is an IF$T^*_{\frac{1}{2}}$ space:

(i) f is an IFG∗CM.

(ii) cl(f(A)) ⊆ f(cl(A)) for each IFS A of X.

(iii) f^{-1}(cl(B)) ⊆ cl(f^{-1}(B)) for each IFS B of Y.

Proof: (i) ⇔ (ii) is obvious from Theorem 3.16

(ii) ⇒ (iii) Let B be an IFS in Y. Then f^{-1}(B) is an IFS in X. Since f is onto, cl(B) = cl(f(f^{-1}(B)). By assumption, cl(f(f^{-1}(B))) ⊆ f(cl(f^{-1}(B))). Therefore cl(B) ⊆ f(cl(f^{-1}(B))). Hence f^{-1}(cl(B)) ⊆ cl(f^{-1}(B)).

(iii) ⇒ (ii) Let A be any IFS of X. Then f(A) is an IFS of Y. Since f is one to one and by assumption f^{-1}(cl(f(A))) ⊆ cl(f^{-1}(f(A))) = cl(A). Therefore f(f^{-1}(cl(f(A)))) ⊆ f(cl(A)). Since f is onto cl(f(A))) ⊆ f(f^{-1}(cl(f(A)))) ⊆ f(cl(A)).

Theorem 3.18: Let f : X → Y be an IFG∗CM where Y is an IF$T^*_{\frac{1}{2}}$ space. Then f is an IFCM.

Proof: Let f be an IFG∗CM. Then for every IFCS A in X, f(A) is an IFG∗CS in Y. Since Y is an IF$T^*_{\frac{1}{2}}$ space, f(A) is an IFCS in Y. Hence f is an IFCM.

Theorem 3.19: Let f : X → Y be an IFG∗CM where Y is an IF$T^*_{\frac{1}{2}}$ space. Then f is an IFPRCM.

Proof: Let A be an IFRCS in X. Since every IFRCS is an IFCS, A is an IFCS in X. By hypothesis, f(A) is an IFG∗CS. Since Y is an IF$T^*_{\frac{1}{2}}$ space, f(A) is an IFCS in Y and hence f(A) is an IFRCS in Y. This implies f is an IFPRCM.

Theorem 3.20: A mapping f : X → Y is an IFG∗CM if and only if for every IFS B of Y and every IFOS U containing f^{-1}(B), there is an IFG∗OS A of Y such that B ⊆ A and f^{-1}(A) ⊆ U.

Proof: Necessity: Suppose f is an IFG∗CM. Let S ⊆ Y and U be an IFOS of X such that f^{-1}(S) ⊆ U. Then A = $\overline{f(\overline{\mathrm{U}})}$ is an IFG∗OS of Y containing S such that f^{-1}(A) ⊆ U.

Sufficient: Let S be an IFCS of X. Then $f^{-1}(\overline{(f(\mathrm{S}))}) \subseteq \overline{\mathrm{S}}$ and $\overline{\mathrm{S}}$ be an IFOS. By Assumption there exist an IFG∗OS V of Y such that $\overline{f(S)} \subseteq V$ and $f^{-1}(\mathrm{V}) \subseteq \overline{\mathrm{S}}$ and so $S \subseteq \overline{(f^{-1}(\mathrm{V}))}$. Hence $\overline{\mathrm{V}} \subseteq f(S) \subseteq f\left(\overline{(f^{-1}(\mathrm{V}))}\right) \subseteq \overline{\mathrm{V}}$ implies $f(S) = \overline{\mathrm{V}}$. Since $\overline{\mathrm{V}}$ is an IFG∗CS, f(S) is an IFG∗CS in Y and therefore f is an IFG∗CM.

Theorem 3.21: If f : X → Y is an IFCM and g: Y → Z is an IFG∗CM, then g ○ f is an IFG∗CM.

Proof: Let A be an IFCS in X. Then f(A) is an IFCS in Y, since f is an IFCM. Also g is an IFG∗CM, g(f(A)) is an IFG∗CM in Z. Therefore g ○ f= g(f(A)) is an IFG∗CM.

Theorem 3.22: If f : X → Y and g: Y → Z are an IFG∗CM and Y is an IF$T^*_{\frac{1}{2}}$ space, then g ○ f is an IFG∗CM.

Proof: Let A be an IFCS in X. Since f is an IFG∗CM, f(A) is an IFG∗CS in Y. Since Y is an IF$T^*_{\frac{1}{2}}$ space, f(A) is an IFCS in Y. By assumption g(f(A)) is an IFG∗CS in Z. Hence g ○ f = g(f(A)) is an IFG∗CS in Z. Therefore g ○ f is an IFG∗CM.

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