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One day International Conference
EMERGING TRENDS IN SCIENCE AND TECHNOLOGY (ETIST-2021)

27th October 2021

Jointly Organized by

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.

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Bipolar Pythagorean Fuzzy Contra Regular α Generalized Continuous Mappings

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ABSTRACT: The impact factor of this paper is to introduce and study the concept of Contra Regular α Generalized Continuous Mappings in Bipolar Pythagorean Fuzzy Topological spaces. Further, we study some of their properties and inter relationship with other existing Bipolar Pythagorean Fuzzy mappings in Bipolar Pythagorean Fuzzy Topological Spaces.
KEYWORDS: Bipolar Pythagorean Fuzzy Sets, Bipolar Pythagorean Fuzzy Topology, Bipolar Pythagoren Fuzzy Regular α Generalized Closed sets, Bipolar Pythagorean Fuzzy Regular α generalized continuous mappings, Bipolar Pythagorean Fuzzy Contra Regular α generalized continuous mappings.

1.INTRODUCTION

In 1965, Zadeh[12] introduced the concept of Fuzzy set which has a framework to encounter uncertainity, 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 extensions of fuzzy set theory, a new concept called intuitionistic Fuzzy set[2] was introduced. In intuitionistic Fuzzy set with elements comprising membership and non membership degree. Yager[3] familarized the model of Pythagorean fuzzy sets. After the Pythagorean fuzzy sets, it was widely used in the field of decision making and was applied for the real life applications. Zhang [11] introduced the extension of fuzzy set with Bipolarity, called Bipolar value fuzzy sets. Chen et.al[10] develops extension of bipolar fuzzy sets.

In this paper, we introduce Bipolar Pythagorean Fuzzy Contra Regular α Generalized Continuous Mappings.

2. PRELIMINARIES

Definition 2.1: Let X be a non empty set. A Bipolar Pythagorean Fuzzy Set(BPFS in short)$A = \{(x, \mu_A^+, \mu_A^-, \nu_A^+, \nu_A^-): x \in X\}$where $\mu_A^+: X \to [0,1], \nu_A^+: X \to [0,1], \mu_A^-: X \to [-1,0], \nu_A^-: X \to [-1,0]$ are the mappings such that $0 \leqslant (\mu_A^+(x))^2 + (\nu_A^+(x))^2 \leqslant 1$ and $-1 \leqslant (\mu_A^-(x))^2 + (\nu_A^-(x)^2 \leqslant 0$ where $\mu_A^+(x)$ denote the positive

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membership degree. $\nu_A^+(x)$ denote the positive non membership degree. $\mu_A^-(x)$ denote the negative membership degree. $\nu_A^-(x)$ denote the negative non membership degree.

Definition 2.2: Let $X \neq \emptyset$ be a set and τ_p be a family of Bipolar Pythagorean Fuzzy subsets of X. If

(a) $0_X, 1_X \in \tau_p$.

(b) For any $P_1, P_2 \in \tau_p$, we have $P_1 \cap P_2 \in \tau_p$.

(c) $\cup P_i \in \tau_p$ for an arbitrary family $\{P_i : i \in J\} \subseteq \tau_p$.

Then τ_p is called Bipolar Pythagorean Fuzzy Topology(BPFT) on X and the pair (X, τ_p) is said to be Bipolar Pythagorean Fuzzy Topological space. Each member of τ_p is called Bipolar Pythagorean Fuzzy open set (BPFOS). The complement of a Bipolar Pythagorean Fuzzy open set is called a Bipolar Pythagorean Fuzzy closed set (BPFCS).

Definition 2.3: If BPFS $A = \{\langle x, \mu_A^+(x), \nu_A^+(x), \mu_A^-(x), \nu_A^-(x)\rangle : x \in X\}$ in a BPFTS (X, τ_p) is said to be

(a) Bipolar Pythagorean Fuzzy Semi closed set (BPFSCS) if $int(cl(A)) \subseteq A$

(b) Bipolar Pythagorean Fuzzy Pre-closed set(BPFPCS) if $cl(int(A)) \subseteq A$

(c) Bipolar Pythagorean Fuzzy α closed set (BPFαCS) if $cl(int(cl(A)) \subseteq A$

(d) Bipolar Pythagorean Fuzzy γ closed set (BPFγCS) if $A \subseteq int(cl(A)) \cup cl(int(A))$

(e) Bipolar Pythagorean Fuzzy regular closed set (BPFRCS) if $A = cl(int(A))$

(f) If BPF set A of a BPFTS (X, τ_p) is a Bipolar Pythagorean Fuzzy Regular Generalized closed set(BPFRGCS), if $cl(A) \subseteq U$whenever $A \subseteq U$ and U is BPFROS in X.

(g) If BPF set A of a BPFTS (X, τ_p) is a Bipolar Pythagorean Fuzzy Regular α Generalized closed set(BPFRGCS), if $\alpha cl(A) \subseteq U$whenever $A \subseteq U$ and U is BPFROS in X.

Definition 2.4: A function $\phi : (X, \tau_p) \to (Y, \sigma_p)$ is called BPFRαG continuous mapping if the inverse image of every BPF closed set in Y is BPFRαG closed set in X.

Definition 2.5: A mapping $\phi : (X, \tau_p) \to (Y, \sigma_p)$ is said to be

(i) BPF semi continuous mapping if $\phi^{-1}(A) \in BPFSO(X)$ for every $A \in (Y, \sigma_p)$.

(ii) BPFα continuous mapping if $\phi^{-1}(A) \in BPF\alpha O(X)$ for every $A \in (Y, \sigma_p)$.

(iii) BPF Pre continuous mapping if $\phi^{-1}(A) \in BPFPO(X)$ for every $A \in (Y, \sigma_p)$.

(iv) BPFγ continuous mapping if $\phi^{-1}(A) \in BPF\gamma O(X)$ for every $A \in (Y, \sigma_p)$.

Definition 2.6: A mapping $\phi : (X, \tau_p) \to (Y, \sigma_p)$ is said to be Bipolar Pythagorean Fuzzy ConratαG continuous mapping (BPF contraαG continuous mapping) if $\phi^{-1}(A) \in BPF\alpha GOS(X)$ for every BPFCS A in (Y, σ_p).

3. BIPOLAR PYTHAGOREAN FUZZY CONTRA REGULAR α GENERALIZED CONTINUOUS MAPPINGS

In this section we introduce Bipolar Pythagorean Fuzzy Contra Regular α Generalized continuous mappings and study some of its properties.

Definition 3.1: A mapping $\phi : (X, \tau_p) \to (Y, \sigma_p)$ is called Bipolar phythagorean fuzzy contra regular α generalized continuous (BPFCRαG continuous in short) mapping if $\phi^{-1}(\omega)$ is a BPFRαGCS in X for every BPFOS ω of Y.

Example 3.2: Let X={a,b} and Y={u,v}. Then $\tau_p = \{0_p, T_1, T_2, 1_p\}$ and $\sigma_p = \{0_p, T_3, 1_p\}$ are BPFTs on X and Y respectively, where T_1= (x, (0.7, 0.6), (0.5, 0.3), (-0.6, -0.7), (-0.4, -0.3)), T_2 = (x, (0.3, 0.2), (0.7, 0.6), (-0.2, -0.1), (-0.8, -0.7)) and T_3 = (y, (0.4, 0.2), (0.8, 0.7), (-0.5, -0.3), (-0.8, -0.7)). Define a mapping $\phi: (X, \tau_p) \to (Y, \sigma_p)$ by $\phi(a) = u$ and $\phi(b) = v$. Here T_3 = (y, (0.4, 0.2), (0.8, 0.7), (-0.5, -0.3), (-0.8, -0.7)) is BPFOS in Y and T_1, T_2 are BPFROS in X. Now $\phi^{-1}(T_3)$ = (x, (0.4, 0.2), (0.8, 0.7), (-0.5, -0.3), (-0.8, -0.7)) is a BPFRαGCS in X, as $\alpha cl(\phi^{-1}(T_3)) = T_1^c \subseteq T_1$ whenever $(\phi^{-1}(T_3)) \subseteq T_1$ and T_1 is BPFROS in X. Therefore, ϕ is BPFCRαG continuous mapping in X.

Remark 3.3: Every BPFC continuous mapping, BPFαC continuous mapping, BPFCR continuous mapping, BPFCG continuous mapping and BPFCαG continuous mapping are BPFCRαG continuous mapping but the converses are .not true. This can be seen from the following examples.

Example 3.4: From Example 3.2, ϕ is BPFCRαG continuous mapping but not BPFC continuous mapping, as $cl(\phi^{-1}(T_3)) = T_1^c \neq \phi^{-1}(T_3)$.

Example 3.5: From Example 3.2, ϕ is BPFCRαG continuous mapping but not BPFαC continuous mapping, as $\alpha cl(\phi^{-1}(T_3)) = cl(int(cl(\phi^{-1}(T_3))) = T_1^c \subseteq \phi^{-1}(T_3)$.

Example: 3.6: From Example 3.2, ϕ is BPFCRαG continuous mapping but not BPFCR continuous mapping, as $\alpha cl(\phi^{-1}(T_3)) = cl(int(cl(\phi^{-1}(T_3))) = T_1^c \subseteq \phi^{-1}(T_3)$.

Example: 3.7: From Example 3.2, ϕ is BPFCRαG continuous mapping but not BPFCG continuous mapping, as $cl(\phi^{-1}(T_3)) = T_2^c \nsubseteq U$.

Example: 3.8: From Example 3.2, ϕ is BPFCRαG continuous mapping but not BPFCαG continuous mapping, as $\alpha cl(\phi^{-1}(T_3)) = cl(int(cl(\phi^{-1}(T_3))) = T_2^c \nsubseteq U$.

Remark 3.9: Every BPFCP continuous mapping and BPFCRαG continuous mapping are independent of each other.

Example 3.10: Let X={a,b} and Y={u,v}. Then $\tau_p = \{0_p, T_1, T_2, 1_p\}$ and $\sigma_p = \{0_p, T_3, 1_p\}$ are BPFTs on X and Y respectively, where T_1= (x, (0.7, 0.6), (0.5, 0.3), (-0.6, -0.7), (-0.4, -0.3)), T_2 = (x, (0.3, 0.2), (0.7, 0.6), (-0.2, -0.1), (-0.8, -0.7)) and T_3 = (y, (0.4, 0.2), (0.5, 0.6), (-0.5, -0.3), (-0.8, -0.7)). Define a mapping $\phi : (X, \tau_p) \to (Y, \sigma_p)$ by $\phi(a) = u$ and $\phi(b) = v$. Here T_3 = (y, (0.4, 0.2), (0.8, 0.7), (-0.5, -0.3), (-0.8, -0.7)) is BPFOS in Y and T_1, T_2 are BPFROS in X. Then $\phi^{-1}(T_3)$ = (x, (0.4, 0.2), (0.8, 0.7), (-0.5, -0.3), (-0.8, -0.7)) is a BPFRαGCS in X but $(\phi^{-1}(T_3))$ is not BPFPCS, as $cl(int((\phi^{-1}(T_3))) = T_1^c \nsubseteq \phi^{-1}(T_3)$. Therefore, ϕ is not a BPFCP continuous mapping in X.

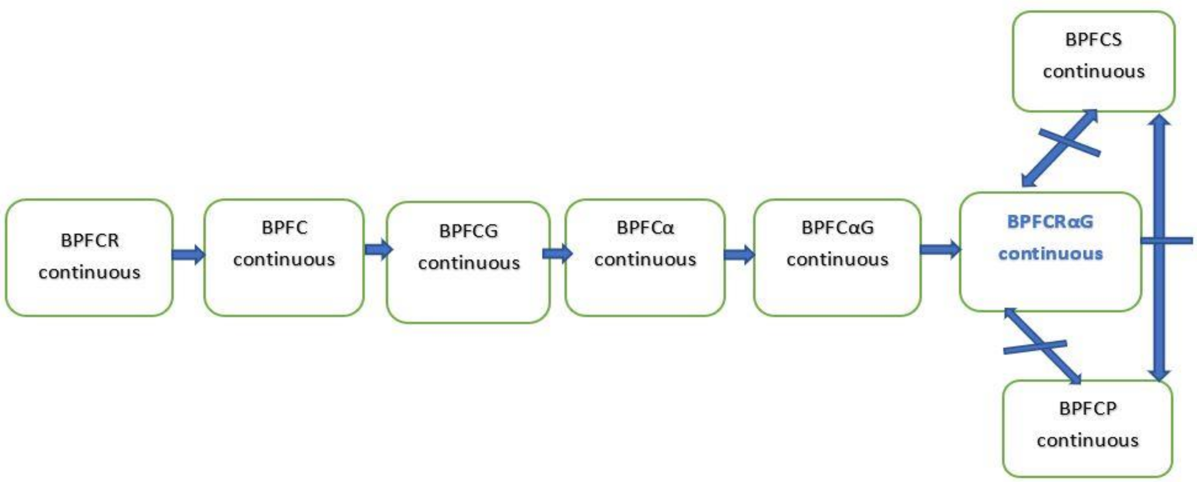
Example 3.11: Let X={a,b} and Y={u,v}. Then $\tau_p = \{0_p, T_1, T_2, 1_p\}$ and $\sigma_p = \{0_p, T_3, 1_p\}$ are BPFTs on X and Y respectively, where T_1= (x, (0.7, 0.6), (0.5, 0.3), (-0.6, -0.5), (-0.4, -0.3)), T_2 = (x, (0.3, 0.2), (0.7, 0.6), (-0.3, -0.1), (-0.7, -0.6)) and T_3 = (y, (0.1, 0.2), (0.8, 0.8), (-0.1, -0.2), (-0.6, -0.6)). Define a mapping $\phi : (X, \tau_p) \to (Y, \sigma_p)$ by $\phi(a) = u$ and $\phi(b) = v$. Here T_3 = (y, (0.1, 0.2), (0.8, 0.8), (-0.1, -0.2), (-0.6, -0.6)) is BPFOS in Y and T_1, T_2 are BPFROS in X. Then $\phi^{-1}(T_3)$ = (x, (0.1, 0.2), (0.8, 0.8), (-0.1, -0.2), (-0.6, -0.6)) is a BPFPCS in X but $(\phi^{-1}(T_3))$ is not BPFRαGCS, as $\alpha cl(\phi^{-1}(T_3)) = T_1^c \subseteq T_1 \nsubseteq T_2$. Therefore, ϕ is not a BPFCRαG continuous mapping in X.

Remark 3.12: Every BPFCS continuous mapping and BPFCRαG continuous mapping are independent of each other.

Example 3.13: From Example 3.10, $\phi^{-1}(T_3)$ = (x, (0.4, 0.2), (0.8, 0.7), (-0.5, -0.3), (-0.8, -0.7)) is a BPFRαGCS in X but $(\phi^{-1}(T_3))$ is not BPFSCS, a s $int(cl((\phi^{-1}(T_3))) = T_1^c \nsubseteq \phi^{-1}(T_3)$. Therefore, ϕ is not a BPFCS continuous mapping in X.

Example 3.14: Let X={a,b} and Y={u,v}. Then $\tau_p = \{0_p, T_1, T_2, 1_p\}$ and $\sigma_p = \{0_p, T_3, 1_p\}$ are BPFTs on X and Y respectively, where T_1= (x, (0.5, 0.3), (0.6, 0.7), (-0.4, -0.2), (-0.5, -0.6)), T_2 = (x, (0.2, 0.2), (0.7, 0.7), (-0.2, -0.1), (-0.5, -0.6)) and T_3 = (y, (0.5, 0.3), (0.6, 0.7), (-0.4, -0.2), (-0.5, -0.6)). Define a mapping $\phi: (X, \tau_p) \to (Y, \sigma_p)$ by $\phi(a) = u$ and $\phi(b) = v$. Here T_3 = (y, (0.1, 0.2), (0.8, 0.8), (-0.1, -0.2), (-0.6, -0.6)) is BPFOS in Y and T_1 is BPFROS in X. Then $\phi^{-1}(T_3)$ = (x, (0.1, 0.2), (0.8, 0.8), (-0.1, -0.2), (-0.6, -0.6)) is a BPFSCS in X but $(\phi^{-1}(T_3))$ is not BPFRαGCS, as $\alpha cl(\phi^{-1}(T_3)) = T_1^c \nsubseteq T_1$. Therefore, ϕ is not a BPFCRαG continuous mapping in X.

Figure 1: The relation between various types of BPFCRG continuous are given in the following diagram



Theorem 3.15: A mapping $\phi: (X, \tau_p) \to (Y, \sigma_p)$ is BPFCRαG continuous mapping if and only if the inverse image of each BPFCS in Y is a BPFRαGOS in X.

Proof: Necessity: Let ω be BPFCS in Y. This implies ω^c is BPFOS in Y. Since ϕ is BPFCRαG continuous mapping, $\phi^{-1}(\omega^c)$ is BPFRαGCS in X. Since $\phi^{-1}(\omega^c) = (\phi^{-1}(\omega))^c$. Thus, $\phi^{-1}(\omega)$ is BPFRαGOS in X.

Sufficiency: Suppose that ω is BPFOS in Y. This implies ω^c is BPFCS in Y. By hypothesis, $\phi^{-1}(\omega^c)$ is BPFRαGOS in X. Since $\phi^{-1}(\omega^c) = (\phi^{-1}(\omega))^c$, where $(\phi^{-1}(\omega))^c$ is BPFRαGOS in X, $\phi^{-1}(\omega)$ is BPFRαGCS in X. Hence ϕ is BPFCRαG continuous mapping.

Theorem 3.16: Let $\phi: (X, \tau_p) \to (Y, \sigma_p)$ be a mapping and let $\phi^{-1}(\omega)$ be a BPFROS in X for every BPFCS ω in Y. Then ϕ is a BPFCRαG continuous mapping.

Theorem 3.17 Let $\phi:(X,\tau_p)\to(Y,\sigma_p)$ be BPFCRαG continuous mapping and $\psi:(Y,\sigma_p)\to(Z,\gamma_p)$ be BPF continuous mapping, then $(\psi\circ\phi):(X,\tau_p)\to(Z,\gamma_p)$ is BPFCRαG continuous mapping.

Theorem 3.18: Let $\phi:(X,\tau_p)\to(Y,\sigma_p)$ be a mapping. Suppose that one of the following properties hold:

(i) $\phi(\alpha cl(\omega))\subseteq int(\phi(\omega))$ for each BPFS ω in X.

(ii) $\alpha cl(\phi^{-1}(\delta))\subseteq\phi^{-1}(int(\delta))$ for each BPFS δ in Y.

(iii) $\phi^{-1}(cl(\delta))\subseteq\alpha int(\phi^{-1}(\delta))$ for each BPFS δ in Y.

Then ϕ is a BPFCRαG continuous mapping.

Proof: (i) ⇒ (ii) Suppose that δ is a BPFS in Y. Then, $\phi^{-1}(\delta)$ is a BPFS in X. By hypothesis, $\phi\left(\alpha cl(\phi^{-1}(\delta))\right)\subseteq int\left(\phi(\phi^{-1}(\delta))\right)\subseteq int(\delta)$.

Now $\alpha cl(\phi^{-1}(\delta))\subseteq\phi^{-1}(\phi(\alpha cl(\phi^{-1}(\delta))))\subseteq\phi^{-1}(int(\delta))$.

(ii) ⇒ (iii) is obvious by taking complement in (ii).

Suppose (iii) holds: Let ω be a BPFCS in Y. Then, $cl(\omega)=\omega$ and $\phi^{-1}(\omega)$ is a BPFS in X. Now $\phi^{-1}(\omega)=\phi^{-1}(cl(\omega))\subseteq\alpha int(\phi^{-1}(\omega))\subseteq\phi^{-1}(\omega)$, by hypothesis. This implies, $\phi^{-1}(\omega)$ is a BPFαOS in X and hence $\phi^{-1}(\omega)$ is a BPFRαGOS in X. Thus ϕ is a BPFCRαG continuous mapping.

Theorem 3.19: A mapping $\phi:(X,\tau_p)\to(Y,\sigma_p)$ is a BPFCRαG continuous mapping if $\phi^{-1}(\alpha cl(\delta))\subseteq int(\phi^{-1}(\delta))$ for every BPFS δ in Y.

Theorem 3.20: A mapping $\phi:(X,\tau_p)\to(Y,\sigma_p)$ is a BPFCRαG continuous mapping, where X is a BPFR$\alpha T_{1/2}$ space if and only if $\phi^{-1}(\alpha cl(\delta))\subseteq\alpha int(\phi^{-1}(cl(\delta)))$ for every BPFS δ in Y.

Proof: Necessity: Let $\delta\subseteq Y$ be a BPFS. Then $cl(\delta)$ is a BPFCS in Y. By hypothesis $\phi^{-1}(cl(\delta))$ is a BPFRαGOS in X. Since X is a BPFR$\alpha T_{1/2}$ space, $\phi^{-1}(cl(\delta))$ is a BPFαOS in X. This implies, $\phi^{-1}(cl(\delta))=\alpha int(\phi^{-1}(cl(\delta)))$. Therefore, $\phi^{-1}(\alpha cl(\delta))\subseteq\phi^{-1}(cl(\delta))=\alpha int(\phi^{-1}(cl(\delta)))$.

Sufficiency: Let $\delta\subseteq Y$ be a BPFS. Then $cl(\delta)$ is a BPFCS in Y. By hypothesis, $\phi^{-1}(\alpha cl(\delta))\subseteq\alpha int(\phi^{-1}(cl(\delta)))=\alpha int(\phi^{-1}(\delta))$. But $\alpha cl(\delta)=\delta$. Therefore, $\phi^{-1}(\delta)=\phi^{-1}(\alpha cl(\delta))\subseteq\alpha int(\phi^{-1}(\delta))\subseteq\phi^{-1}(\delta)$. This implies, $\phi^{-1}(\delta)$ is a BPFαOS in X and hence $\phi^{-1}(\delta)$ is a BPFRαGOS in X. Hence δ is a BPFCRαG continuous mapping.

Theorem 3.21: A BPF continuous mapping $\phi:(X,\tau_p)\to(Y,\sigma_p)$ is a BPFCRαG continuous mapping, if BPFRαGO(X) = BPFRαGC(X).

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