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NEUTROSOPHIC GENERALIZED α-CONTRA-CONTINUITY

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ABSTRACT. In this paper we introduce neutrosophic generalized α-contra-continuous function, neutrosophic strongly generalized α-contra-continuous function, neutrosophic generalized α-contra-irresolute and their interrelations are established with necessary examples.

1. INTRODUCTION AND PRELIMINARIES

Zadeh [14] introduced the concept of fuzzy set. Atanassov [2] introduced the notion of intuitionistic fuzzy set as a generalization of fuzzy set. Coker [4] introduced the notion of intuitionistic fuzzy topological space. The concepts of generalized intuitionistic fuzzy closed set was introduced by Dhavaseelan et al. [5] and also investigated generalized intuitionistic fuzzy contra-continuous functions [6]. F. Smadaranche introduced the notion of neutrosophy and the neutrosophic set [[12], [13]], and A. A. Salama and S. A. Alblowi [11] offered the notions of neutrosophic crisp set and neutrosophic crisp topological space. In this paper, we focus on some versions of Dontchev's notion of contra-continuity [9] in the context of neutrosophic topology such as neutrosophic generalized α-contra-continuous function, neutrosophic strongly generalized α-contra-continuous function, neutrosophic generalized α-contra-irresolute. Moreover, we establish their interrelations with some examples.

Definition 1.1. [12, 13] Let T,I,F be real standard or non standard subsets of $]0^-, 1^+[$, with
$sup_T = t_{sup}, inf_T = t_{inf}$
$sup_I = i_{sup}, inf_I = i_{inf}$
$sup_F = f_{sup}, inf_F = f_{inf}$
$n - sup = t_{sup} + i_{sup} + f_{sup}$
$n - inf = t_{inf} + i_{inf} + f_{inf}$. T,I,F are neutrosophic components.

Definition 1.2. [12, 13] Let X be a nonempty fixed set. A neutrosophic set [NS for short] A is an object having the form $A = \{\langle x, \mu_A(x), \sigma_A(x), \gamma_A(x)\rangle : x \in X\}$ where $\mu_A(x), \sigma_A(x)$ and $\gamma_A(x)$ which represents the degree of membership function (namely $\mu_A(x)$), the degree of indeterminacy (namely $\sigma_A(x)$) and the degree of nonmembership (namely $\gamma_A(x)$) respectively of each element $x \in X$ to the set A.

Remark 1.1. [12, 13]

(1) A neutrosophic set $A = \{\langle x, \mu_A(x), \sigma_A(x), \gamma_A(x)\rangle : x \in X\}$ can be identified to an ordered triple $\langle \mu_A, \sigma_A, \gamma_A\rangle$ in $]0^-, 1^+[$ on X.

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(2) For the sake of simplicity, we shall use the symbol $A = \langle \mu_A, \sigma_A, \gamma_A \rangle$ for the neutrosophic set $A = \{\langle x, \mu_A(x), \sigma_A(x), \gamma_A(x)\rangle : x \in X\}$.

Definition 1.3. [11] Let X be a nonempty set and the neutrosophic sets A and B in the form
$A = \{\langle x, \mu_A(x), \sigma_A(x), \gamma_A(x)\rangle : x \in X\}$, $B = \{\langle x, \mu_B(x), \sigma_B(x), \gamma_B(x)\rangle : x \in X\}$. Then
(a) $A \subseteq B$ iff $\mu_A(x) \leq \mu_B(x)$, $\sigma_A(x) \leq \sigma_B(x)$ and $\gamma_A(x) \geq \gamma_B(x)$ for all $x \in X$;
(b) $A = B$ iff $A \subseteq B$ and $B \subseteq A$;
(c) $\bar{A} = \{\langle x, \gamma_A(x), \sigma_A(x), \mu_A(x)\rangle : x \in X\}$; [Complement of A]
(d) $A \cap B = \{\langle x, \mu_A(x) \wedge \mu_B(x), \sigma_A(x) \wedge \sigma_B(x), \gamma_A(x) \vee \gamma_B(x)\rangle : x \in X\}$;
(e) $A \cup B = \{\langle x, \mu_A(x) \vee \mu_B(x), \sigma_A(x) \vee \sigma_B(x), \gamma_A(x) \wedge \gamma_B(x)\rangle : x \in X\}$;
(f) $[\,]A = \{\langle x, \mu_A(x), \sigma_A(x), 1 - \mu_A(x)\rangle : x \in X\}$;
(g) $\langle\rangle A = \{\langle x, 1 - \gamma_A(x), \sigma_A(x), \gamma_A(x)\rangle : x \in X\}$.

Definition 1.4. [11] Let $\{A_i : i \in J\}$ be an arbitrary family of neutrosophic sets in X. Then
(a) $\bigcap A_i = \{\langle x, \wedge\mu_{A_i}(x), \wedge\sigma_{A_i}(x), \vee\gamma_{A_i}(x)\rangle : x \in X\}$;
(b) $\bigcup A_i = \{\langle x, \vee\mu_{A_i}(x), \vee\sigma_{A_i}(x), \wedge\gamma_{A_i}(x)\rangle : x \in X\}$.

Since our main purpose is to construct the tools for developing neutrosophic topological spaces, we must introduce the neutrosophic sets 0_N and 1_N in X as follows:

Definition 1.5. [11] $0_N = \{\langle x, 0, 0, 1\rangle : x \in X\}$ and $1_N = \{\langle x, 1, 1, 0\rangle : x \in X\}$.

Definition 1.6. [7] A neutrosophic topology (NT) on a nonempty set X is a family T of neutrosophic sets in X satisfying the following axioms:
(i) $0_N, 1_N \in T$,
(ii) $G_1 \cap G_2 \in T$ for any $G_1, G_2 \in T$,
(iii) $\cup G_i \in T$ for arbitrary family $\{G_i \mid i \in \Lambda\} \subseteq T$.
In this case the ordered pair (X, T) or simply X is called a neutrosophic topological space (briefly NTS) and each neutrosophic set in T is called a neutrosophic open set (briefly NOS). The complement $\overline{A}$ of a NOS A in X is called a neutrosophic closed set (briefly NCS) in X.

Definition 1.7. [7] Let A be a neutrosophic set in a neutrosophic topological space X. Then
$Nint(A) = \bigcup\{G \mid G$ is a neutrosophic open set in X and $G \subseteq A\}$ is called the neutrosophic interior of A;
$Ncl(A) = \bigcap\{G \mid G$ is a neutrosophic closed set in X and $G \supseteq A\}$ is called the neutrosophic closure of A.

Definition 1.8. [8] Let (X, T) and (Y, S) be any two neutrosophic topological spaces.
(i) A function $f : (X, T) \to (Y, S)$ is called neutrosophic contra-continuous if the inverse image of every neutrosophic open set in (Y, S) is a neutrosophic closed set in (X, T) .
Equivalently if the inverse image of every neutrosophic closed set in (Y, S) is a neutrosophic open set in (X, T) .
(ii) A function $f : (X, T) \to (Y, S)$ is called generalized neutrosophic contra-continuous if the inverse image of every neutrosophic open set in (Y, S) is a generalized neutrosophic closed set in (X, T) .
Equivalently if the inverse image of every neutrosophic closed set in (Y, S) is a generalized neutrosophic open set in (X, T) .

Definition 1.9. [1] Let f be a function from a neutrosophic topological spaces (X,T) and (Y,S). Then f is called

(i) a neutrosophic open function if $f(A)$ is a neutrosophic open set in Y for every neutrosophic open set A in X.
(ii) a neutrosophic α-open function if $f(A)$ is a neutrosophic α-open set in Y for every neutrosophic open set A in X.
(iii) a neutrosophic preopen function if $f(A)$ is a neutrosophic preopen set in Y for every neutrosophic open set A in X.
(iv) a neutrosophic semiopen function if $f(A)$ is a neutrosophic semiopen set in Y for every neutrosophic open set A in X.

2. Neutrosophic generalized α-contra-continuous function

In this section we introduce neutrosophic generalized α-contra-continuous function and studied some of its properties.

Definition 2.1. A neutrosophic set A in (X,T) is said to be a neutrosophic generalized $alpha$-closed set if $N\alpha cl(A) \subseteq U$ whenever $A \subseteq U$ and U is a neutrosophic α open set in (X,T).

Definition 2.2. A function $f : (X,T) \to (Y,S)$ is called a neutrosophic generalized α-contra-continuous if $f^{-1}(B)$ is a neutrosophic generalized α-closed set in (X,T) for every neutrosophic open set B in (Y,S)

Definition 2.3. A function $f : (X,T) \to (Y,S)$ is called a neutrosophic strongly generalized α- continuous if $f^{-1}(B)$ is a neutrosophic open set in (X,T) for every neutrosophic generalized α-open set B in (Y,S)

Definition 2.4. A function $f : (X,T) \to (Y,S)$ is called a neutrosophic strongly generalized α-contra-continuous if $f^{-1}(B)$ is a neutrosophic closed set in (X,T) for every neutrosophic generalized α-open set B in (Y,S)

Definition 2.5. A function $f : (X,T) \to (Y,S)$ is called a neutrosophic generalized α-contra-irresolute if $f^{-1}(B)$ is a neutrosophic generalized α-closed set in (X,T) for every neutrosophic generalized α-open set B in (Y,S)

Proposition 2.1. For any two neutrosophic topological spaces (X,T) and (Y,S), if $f : (X,T) \to (Y,S)$ is a neutrosophic contra-continuous function then f is a neutrosophic generalized α-contra-continuous function.

Proof. Let B be a neutrosophic open set in (Y,S). Since f is a neutrosophic contra-continuous function, $f^{-1}(B)$ is a neutrosophic closed set in (X,T). Since every neutrosophic closed set is a neutrosophic generalized α-closed set, $f^{-1}(B)$ is a neutrosophic generalized α-closed set in (X,T). Hence f is a neutrosophic generalized α-contra-continuous function. □

The converse of Proposition 2.1 need not be true as shown in Example 2.1.

Example 2.1. Let $X = \{a,b\}$. Define the neutrosophic sets G_1 and G_2 in X as follows: $G_1 = \langle x, (0.6,0.6,0.6), (0.4,0.4,0.4)\rangle$ and $G_2 = \langle x, (0.2,0.2,0.3), (0.8,0.8,0.7)\rangle$. Then the families $T = \{0_N, 1_N, G_1\}$ and $S = \{0_N, 1_N, G_2\}$ are neutrosophic topologies on X. Define a function $f : (X,T) \to (Y,S)$ as follow $f(a) = a, f(b) = b$. Then f is a neutrosophic generalized α-contra-continuous function, but $f^{-1}(G_2)$ is not a neutrosophic closed set in (X,T). Hence f is not a neutrosophic contra-continuous function.

Proposition 2.2. For any two neutrosophic topological spaces (X,T) and (Y,S), if $f : (X,T) \to (Y,S)$ is a neutrosophic α-contra-continuous function then f is a neutrosophic generalized α-contra-continuous function.

Proof. Let B be a neutrosophic open set in (Y,S). Since f is a neutrosophic α-contra-continuous function, $f^{-1}(B)$ is a neutrosophic α-closed set in (X,T). Since every neutrosophic α-closed set is a neutrosophic generalized α-closed set, $f^{-1}(B)$ is a neutrosophic generalized α-closed set in (X,T). Hence f is a neutrosophic generalized α-contra-continuous function. □

The converse of Proposition 2.2 need not be true as shown in Example 2.2.

Example 2.2. Let $X = \{a,b\}$. Define the neutrosophic sets G_1 and G_2 in X as follows:
$G_1 = \langle x,(0.5,0.5,0.5),(0.5,0.5,0.5)\rangle$ and $G_2 = \langle x,(0.4,0.4,0.4),(0.6,0.6,0.6)\rangle$. Then the families $T = \{0_N, 1_N, G_1\}$ and $S = \{0_N, 1_N, G_2\}$ are neutrosophic topologies on X. Define a function $f : (X,T) \to (Y,S)$ as follow $f(a) = a, f(b) = b$. Then f is a neutrosophic generalized α-contra-continuous function, but $f^{-1}(G_2)$ is not a neutrosophic α-closed set in (X,T). Hence f is not a neutrosophic α-contra-continuous function.

Proposition 2.3. For any two neutrosophic topological spaces (X,T) and (Y,S), if $f : (X,T) \to (Y,S)$ is a neutrosophic strongly generalized α-contra-continuous function then f is a neutrosophic generalized α-contra-continuous function.

Proof. Let B be a neutrosophic open set in (Y,S). Every neutrosophic open set is a neutrosophic generalized α-open set. Now, B is a neutrosophic generalized α-open set in (Y,S). Since f is a neutrosophic strongly generalized α-contra continuous function, $f^{-1}(B)$ is a neutrosophic closed set in (X,T). Since every neutrosophic closed set is a neutrosophic generalized α-closed set, $f^{-1}(B)$ is a neutrosophic generalized α-closed set in (X,T). Hence f is a neutrosophic generalized α-contra-continuous function. □

The converse of Proposition 2.3 need not be true as shown in Example 2.3.

Example 2.3. Let $X = \{a,b\}$. Define the neutrosophic sets G_1 and G_2 in X as follows:
$G_1 = \langle x,(0.4,0.4,0.4),(0.3,0.3,0.3)\rangle$ and $G_2 = \langle x,(0.2,0.2,0.3),(0.8,0.8,0.7)\rangle$. Then the families $T = \{0_N, 1_N, G_1\}$ and $S = \{0_N, 1_N, G_2\}$ are neutrosophic topologies on X. Define a function $f : (X,T) \to (Y,S)$ as follow $f(a) = a, f(b) = b$. Then f is a neutrosophic generalized α-contra-continuous function. Let $A = \langle x,(0.4,0.4,0.4),(0.6,0.6,0.6)\rangle$ is a neutrosophic generalized α-open set in (X,T), but $f^{-1}(A)$ is not a neutrosophic closed set in (X,T). Hence f is not a neutrosophic strongly generalized α-contra-continuous function.

Proposition 2.4. For any two neutrosophic topological spaces (X,T) and (Y,S), if $f : (X,T) \to (Y,S)$ is a neutrosophic strongly generalized α-contra-continuous function then f is a neutrosophic contra-continuous function.

Proof. Let B be a neutrosophic open set in (Y,S). Every neutrosophic open set is a neutrosophic generalized α-open set. Now, B is a neutrosophic generalized α-open set in (Y,S). Since f is a neutrosophic strongly generalized α-contra-continuous function, $f^{-1}(B)$ is a neutrosophic closed set in (X,T). Hence f is a neutrosophic contra-continuous function. □

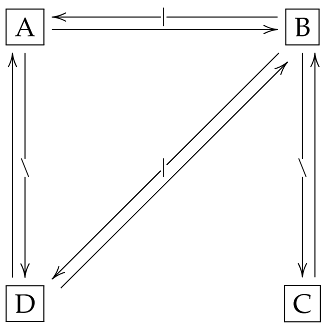
The converse of Proposition 2.4 need not be true as shown in Example 2.4.

Example 2.4. Let $X = \{a, b\}$. Define the neutrosophic sets G_1 and G_2 in X as follows: $G_1 = \langle x, (0.3, 0.3, 0.3), (0.7, 0.7, 0.7)\rangle$ and $G_2 = \langle x, (0.7, 0.7, 0.7), (0.3, 0.3, 0.3)\rangle$. Then the families $T = \{0_N, 1_N, G_1\}$ and $S = \{0_N, 1_N, G_2\}$ are neutrosophic topologies on X. Define a function $f : (X, T) \to (Y, S)$ as follow $f(a) = a, f(b) = b$. Then f is a neutrosophic contra continuous function. Let $A = \langle x, (0.35, 0.35, 0.4), (0.5, 0.5, 0.6)\rangle$ is a neutrosophic generalized α-closed set in (X, T), but $f^{-1}(A)$ is not a neutrosophic open set in (X, T). Hence f is not a neutrosophic strongly generalized α-contra-continuous function.

INTERRELATIONS

From the above results proved, we have a diagram of implications as shown below.

In the diagram, A, B, C and D denote a neutrosophic contra continuous function,neutrosophic generalized α-contra-continuous function,neutrosophic α-contra-continuous function and neutrosophic strongly generalized α-contra-continuous function respectively.



Proposition 2.5. Let (X, T) , (Y, S) and (Z, R) be any three neutrosophic topological spaces. If a function $f : (X, T) \to (Y, S)$ is a neutrosophic strongly generalized α-continuous function and $g : (Y, S) \to (Z, R)$ is a neutrosophic generalized α-contra-continuous function then $g \circ f$ is a neutrosophic contra-continuous function function.

Proof. Let V be a neutrosophic open set of (Z, R). Since g is a neutrosophic generalized α-contra-continuous function, $g^{-1}(V)$ is neutrosophic generalized α-closed set in (Y, S). Since f is a neutrosophic strongly generalized α-continuous function, $f^{-1}(g^{-1}(V))$ is a neutrosophic closed set in (X, T). Hence $g \circ f$ is a neutrosophic contra-continuous function. □

Proposition 2.6. Let (X, T) , (Y, S) and (Z, R) be any three neutrosophic topological spaces. Then the following statements hold:

(i) If f is a neutrosophic generalized α-contra-continuous function and g is a neutrosophic continuous function, then $g \circ f$ is a neutrosophic generalized α-contra-continuous function.

(ii) If f is a neutrosophic generalized α-contra-continuous function and g is a neutrosophic contra-continuous function, then $g \circ f$ is a neutrosophic generalized α-continuous function.

(iii) If f is a neutrosophic generalized α-contra-irresolute function and g is a neutrosophic generalized α-contra-continuous function, then $g \circ f$ is a neutrosophic generalized α-continuous function.

(iv) If f is a neutrosophic generalized α-irresolute function and g is a neutrosophic generalized α-contra-continuous function, then $g \circ f$ is a neutrosophic generalized α-contra-continuous function.

Proof.

(i) Let B be a neutrosophic open set of (Z, R). Since g is a neutrosophic continuous function, $g^{-1}(B)$ is neutrosophic open set in (Y, S). Since f is a neutrosophic generalized α-contra-continuous function, $f^{-1}(g^{-1}(B))$ is a neutrosophic generalized α-closed set in (X, T). Hence $g \circ f$ is a neutrosophic generalized α-contra-continuous function.

(ii) Let B be a neutrosophic open set of (Z, R). Since g is a neutrosophic contra-continuous function, $g^{-1}(B)$ is neutrosophic closed set in (Y, S). Since f is a neutrosophic generalized α-contra-continuous function, $f^{-1}(g^{-1}(B))$ is a neutrosophic generalized α-open set in (X, T). Hence $g \circ f$ is a neutrosophic generalized α-continuous function.

(iii) Let B be a neutrosophic open set of (Z, R). Since g is a neutrosophic generalized α-contra -continuous function, $g^{-1}(B)$ is neutrosophic generalized α-closed set in (Y, S). Since f is a neutrosophic generalized α-contra-irresolute function, $f^{-1}(g^{-1}(B))$ is a neutrosophic generalized α-open set in (X, T). Hence $g \circ f$ is a neutrosophic generalized α-continuous function.

(iv) Let B be a neutrosophic open set of (Z, R). Since g is a neutrosophic generalized α-contra -continuous function, $g^{-1}(B)$ is neutrosophic generalized α-closed set in (Y, S). Since f is a neutrosophic generalized α-irresolute function, $f^{-1}(g^{-1}(B))$ is a neutrosophic generalized α-closed set in (X, T). Hence $g \circ f$ is a neutrosophic generalized α-contra-continuous function.

□

Definition 2.6. Let (X, T) and (Y, S) be any two neutrosophic topological spaces. Let $f : (X, T) \to (Y, S)$ be a function. The graph $g : X \to X \times Y$ of f is defined by $g(x) = (x, f(x)), \forall x \in X$.

Proposition 2.7. Let (X, T) and (Y, S) be any two neutrosophic topological spaces.Let $f : (X, T) \to (Y, S)$ be a function. If the graph $g : X \to X \times Y$ of f is a neutrosophic generalized α-contra-continuous function then f is also a neutrosophic generalized α-contra-continuous function.

Proof. Let B be a neutrosophic closed set in (Y, S). By definition 2.6., $f^{-1}(B) = 1_N \cap f^{-1}(B) = g^{-1}(1_N \times B)$. Since g is a neutrosophic generalized α-contra-continuous function, $g^{-1}(1_N \times B)$ is a neutrosophic generalized α-open set in (X, T). Now, $f^{-1}(B)$ is a neutrosophic generalized α-open set in (X, T). Hence f is a neutrosophic generalized α-contra -continuous function. □

Proposition 2.8. Let (X, T) and (Y, S) be any two neutrosophic topological spaces. Let $f : (X, T) \to (Y, S)$ be a function. If the graph $g : X \to X \times Y$ of f is a neutrosophic strongly generalized α-contra-continuous function then f is also a neutrosophic strongly generalized α-contra-continuous function.

Proof. Let B be a neutrosophic generalized α-open set in (Y, S). By definition 2.6., $f^{-1}(B) = 1_N \cap f^{-1}(B) = g^{-1}(1_N \times B)$. Since g is a neutrosophic strongly generalized α-contra- continuous function, $g^{-1}(1_N \times B)$ is a neutrosophic closed set in (X, T). Now, $f^{-1}(B)$ is a neutrosophic closed set in (X,T). Hence f is an a neutrosophic strongly generalized α-contra-continuous function. □

Proposition 2.9. Let (X,T) and (Y,S) be any two neutrosophic topological spaces. Let $f:(X,T)\to(Y,S)$ be a function. If the graph $g:X\to X\times Y$ of f is a neutrosophic generalized α-contra-irresolute function then f is also a neutrosophic generalized α-contra-irresolute function.

Proof. Let B be a neutrosophic generalized α-closed set in (Y,S). By definition 2.6., $f^{-1}(B)=1_N\cap f^{-1}(B)=g^{-1}(1_N\times B)$. Since g is a neutrosophic generalized α-contra-irresolute function, $g^{-1}(1_N\times B)$ is a neutrosophic generalized α-open set in (X,T). Now, $f^{-1}(B)$ is a neutrosophic generalized α-open set in (X,T). Hence f is an a neutrosophic generalized α-contra-irresolute function. □

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