Neutrosophic Generalized Regular Contra Continuity in Neutrosophic Topological Spaces

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Abstract- In this paper, the concept of Neutrosophic generalized regular contra continuous mapping are introduced. Furthermore Neutrosophic generalized regular contra irresolute mapping, Strongly Neutrosophic generalized regular contra continuous mapping and Perfectly Neutrosophic generalized regular contra continuous mapping are introduced in Neutrosophic topological spaces.

Index terms- Neutrosophic generalized regular contra continuity; Neutrosophic generalized regular contra irresolute; Strongly Neutrosophic generalized regular contra continuity and Perfectly Neutrosophic generalized regular contra continuity.

1. INTRODUCTION

Topology is a classical subject, as a generalization of topological spaces many type of topological spaces introduced over the year. C.L.Chang[6] introduced and developed fuzzy topological space by using L.A. Zadeh[19] fuzzy sets. Coker[7] introduced the notion of Intuitionistic fuzzy topological spaces by using Atanassov[3] intuitionistic fuzzy set .Neutrality the degree of indeterminacy, as an independent concept, was introduced by Smarandache[13] He also defined the Neutrosophic set on three component Neutrosophic topological spaces (t,f,i) =(Truth, Falsehood, Indeterminacy). The Neutrosophic crisp set concept was converted to Neutrosophic topological spaces by A.A.Salama[16]. R.Dhavaseelan[8] introduced Neutrosophic generalized closed sets. V.K.Shanthi[18] introduced Neutrosophic Generalized Semi Closed Sets In Neutrosophic Topological Spaces. A.A.Salama[17] introduced Neutrosophic Closed Set and Neutrosophic Continuous Functions. R.Dhavaseelan [11] investigated Generalized intuitionistic fuzzy contra-continuous functions and Dontchev [12] studied the concept of Contra continuous functions and strongly S-closed spaces. R. Dhavaseelan [9] introduced the concept of Neutrosophic generalized α contra-continuity.

2. PRELIMINARIES

Definition 2.1 *[8,9]*
Let X be a non-empty fixed set. A Neutrosophic set A has the form
$A = \{(x,\mu_A(x), \sigma_A(x), \gamma_A(x)) : x \in X\}$
where $\mu_A(x)$, $\sigma_A(x)$, $\gamma_A(x)$ are topological spaces and $\mu_A(x)$ is the degree of membership function, $\sigma_A(x)$ is the degree of indeterminacy and $\gamma_A(x)$ is the degree of non-membership function respectively of each $x \in X$ to the set A.

Remark 2.2 *[8,9]*
A Neutrosophic set $A = \{(x,\mu_A(x), \sigma_A(x), \gamma_A(x)) : x \in X\}$ can be identified to an ordered triple $(\mu_A, \sigma_A, \gamma_A)$ in $]0^-, 1^+[$on X.

Example 2.3 *[8,9]*
Since our main purpose is to construct the tools for developing Neutrosophic set and Neutrosophic topology, we must introduce the Neutrosophic set 0_N and 1_N in X as follows:
$0_N = \{(x, 0, 0, 1): x \in X\}$
$1_N = \{(x, 1, 0, 0): x \in X\}$

Definition 2.4 *[4]*
Let $A = \{(x,\mu_A, \sigma_A, \gamma_A)\}$ be Neutrosophic set on X , then Complement of set A i.e., A^C is defined as $A^C=\{(x, \gamma_A(x),1\text{-}\sigma_A(x), \mu_A(x)): x \in X\}$.

Definition 2.5 *[8,9]*
Let X be a non-empty set and A and B are Neutrosophic sets of the form
$A = \{(x,\mu_A(x), \sigma_A(x), \gamma_A(x)) : x \in X\}$ and
$B = \{(x,\mu_B(x), \sigma_B(x), \gamma_B(x)) : x \in X\}$ then we consider the definition of subset ($A \subseteq B$) is defined as $A \subseteq B \Leftrightarrow \mu_A(x) \le \mu_B(x), \sigma_A(x) \le \sigma_B(x), \gamma_A(x) \ge \gamma_B(x)$, for all $x \in X$.

Theorem 2.6 *[4]*
For any Neutrosophic set A the following condition holds
(i) $0_N \subseteq A$, $0_N \subseteq 0_N$,
(ii) $A \subseteq 1_N$, $1_N \subseteq 1_N$.

Definition 2.7 *[8,9]*
Let X be a non-empty set and
$A = \{x, \mu_A(x), \sigma_A(x), \gamma_A(x)\}$ and

$B = \{x, \mu_B(x), \sigma_B(x), \gamma_B(x)\}$ are Neutrosophic sets then $A \cap B$ is defined as

$A \cap B = \{x, \mu_A(x) \wedge \mu_B(x), \sigma_A(x) \wedge \sigma_B(x), \gamma_A(x) \vee \gamma_B(x)\}$

then $A \cup B$ is defined as

$A \cup B = \{x, \mu_A(x) \vee \mu_B(x), \sigma_A(x) \vee \sigma_B(x), \gamma_A(x) \wedge \gamma_B(x)\}$.

Definition 2.8 *[8,9]*
A Neutrosophic topology is a non-empty set X is an family τ_N of Neutrosophic subsets in X satisfying the axioms:
(i) 0_N , $1_N \in \tau_N$
(ii) $G_1 \cap G_2 \in \tau_N$ for any $G_1, G_2 \in \tau_N$
(iii) $\cup G_i \in \tau_N$ for every $\{ G_j$:j∈J$\} \subseteq \tau_N$
the pair (X, τ_N) is called Neutrosophic topological space.
The element in Neutrosophic topological space (X, τ_N) are called Neutrosophic open sets.
A Neutrosophic set F is closed if and only if $(F)^C$ is Neutrosophic open.

Definition 2.9 *[8,9]*
Let (X, τ_N) Neutrosophic topological spaces and
$A = \{(x, \mu_A(x), \sigma_A(x), \gamma_A(x)) : x \in X\}$ be Neutrosophic set in X. Then the
Neutrosophic closure and *Neutrosophic interior* are defined as
$Ncl(A) = \cap$ {K:K is Neutrosophic closed set in X and $A \subseteq K$},
$Nint(A) = \cup$ {G:G is Neutrosophic open set in X and $G \subseteq A$}.

Definition 2.10 *[4]*
A is Neutrosophic open set if and only if
A = *Nint(A),*
A is Neutrosophic closed set if and only if
A = *Ncl(A).*

Theorem 2.11 *[4]*
Let (X, τ_N) Neutrosophic topological spaces and A, B be two Neutrosophic sets in X. Then the following properties holds:
(i) $A \subseteq B \Rightarrow Nint(A) \subseteq Nint(B)$,
(ii) $A \subseteq B \Rightarrow Ncl(A) \subseteq Ncl(B)$,
(iii) $Nint(Nint(A))=Nint(A)$,
(iv) $Ncl(Ncl(A))=Ncl(A)$,
(v) $Nint(A \cap B) = Nint(A) \cap Nint(B)$,
(vi) $Ncl(A \cup B) = Ncl(A) \cup Ncl(B)$,
(vii) $Nint(0_N)=0_N$,
(viii) $Nint(1_N)=1_N$,
(ix) $Ncl(0_N)=0_N$,
(x) $Ncl(1_N)=1_N$,
(xi) $Ncl(A \cap B) \subseteq Ncl(A) \cap Ncl(B)$,
(xii) $Nint(A \cup B) \supseteq Nint(A) \cup Nint(B)$.

Definition 2.12 *[2,4]*
A subset A of Neutrosophic space (X, τ_N) is called Neutrosophic regular open (in short *NR open*) if
$A = Nint(Ncl(A))$ .The Complement of *NR open* set is called *NR closed.*

Definition 2.13 *[4]*
A subset A of Neutrosophic space (X, τ_N) is called Neutrosophic generalized closed (in short *NG closed*) if $Ncl(A) \subseteq U$, whenever $A \subseteq U$ and U is Neutrosophic open. The Complement of a *NG closed* set is called *NG open* set.

Definition 2.14 *[4]*
Let A be a subset of Neutrosophic space (X, τ_N) is called Neutrosophic generalized regular closed *(NGR closed)* if *Neutrosophic Regular* $cl(A) \subseteq U$
(in short $NRcl(A) \subseteq U$), whenever $A \subseteq U$ and U is Neutrosophic open.The Complement of a *NGR closed* set is called *NGR open* set.

Definition 2.15 *[5]*
Let (X, T) and (Y, S) be any two Neutrosophic topological spaces

(i) A map $f : (X, T) \rightarrow (Y, S)$ is said to be *Neutrosophic continuous* if the inverse image of every Neutrosophic closed set in (Y,S) is *Neutrosophic closed* set in (X, T).

Definition 2.16 *[5]*
Let (X, T) and (Y, S) be any two Neutrosophic topological spaces
(i) A map $f : (X, T) \rightarrow (Y, S)$ is said to be *Neutrosophic generalized regular continuous* (in short *NGR continuous*) if the inverse image of every *Neutrosophic closed* set in (Y, S) is *NGR closed* set in (X, T).

(ii) A map $f : (X, T) \rightarrow (Y, S)$ is said to be *Neutrosophic generalized regular irresolute* (in short *NGR irresolute*) if the inverse image of every *NGR closed* set in (Y, S) is *NGR closed* set in (X, T).

(iii) A map $f : (X,T) \rightarrow (Y,S)$ is said to be *Strongly Neutrosophic generalized regular continuous* (in short *Strongly NGR continuous*) if the inverse image of every *NGR open* set in (Y, S) is an *Neutrosophic open* set in (X, T) .

Definition 2.17 *[9]*
Let (X, T) and (Y, S) be any two neutrosophic topological spaces.

(i) A function $f : (X, T) \rightarrow (Y, S)$ 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) .

(ii) A function $f : (X, T) \rightarrow (Y, S)$ is called *Neutrosophic generalized contra- continuous* (in short *NG contra- continuous*) if the inverse image of every *Neutrosophic open* set in (Y, S) is a *NG closed* set in (X, T) .

3. NEUTROSOPHIC GENERALIZED REGULAR CONTRA CONTINUITY

Definition 3.1

Let (X, T) and (Y, S) be any two Neutrosophic topological spaces.

(i) A function $f : (X, T) \rightarrow (Y, S)$ is said to be *Neutrosophic regular contra-continuous* (in short *NR contra-continuous*) if the inverse image of every *Neutrosophic open* set in (Y, S) is *NR closed* set in (X, T).

(ii) A function $f : (X, T) \rightarrow (Y, S)$ is called a *Neutrosophic generalized regular contra-continuous* (in short *NGR contra-continuous*) if $f^{-1}(B)$ is a *NGR closed* set in (X, T) for every*Neutrosophic open* set B in (Y, S) .

(iii) A function $f : (X, T) \rightarrow (Y, S)$ is called a *Strongly Neutrosophic generalized regular contra-continuous* (in short *Strongly NGR contra-continuous*) if $f^{-1}(B)$ is a *Neutrosophic closed* set in (X, T) for every *NGR open* set B in (Y, S).

(iv) A function $f : (X, T) \rightarrow (Y, S)$ is called a *Neutrosophic generalized regular contra irresolute* (in short *NGR contra irresolute*), if $f^{-1}(B)$ is a *NGR closed set* in (X, T) for every *NGR open* set B in (Y, S).

Theorem 3.2

Let (X, T) and (Y, S) be any two Neutrosophic topological spaces. If $f : (X, T) \rightarrow (Y, S)$ be Neutrosophic contra-continuous function. Then it is a NGR contra-continuous mapping.

Proof:

Let B be a *Neutrosophic open* sets in (Y, S)

Since f is *Neutrosophic contra-continuous* function ,

By definition 2.17(i) , $f^{-1}(B)$ is *Neutrosophic closed* set in (X,T).

We know, Every *Neutrosophic closed* set is *NGR closed* set.

Now $f^{-1}(B)$ is *NGR closed* set in (X, T).

Therefore By definition 3.1(ii), f is *NGR contra-continuous* mapping . Hence proved.

The converse of theorem 3.2 need not be true as shown in example 3.2.1

Example 3.2.1

Let $X = \{a, b\}$ and where $A = \{(0.6, 0.6, 0.6), (0.4, 0.4, 0.4)\}$ and $B = \{(0.2, 0.2, 0.3), (0.8, 0.8, 0.7)\}$ is Neutrosophic sets. Then the families $T = \{0_N , 1_N , A\}$ and $S = \{0_N , 1_N , B\}$are Neutrosophic topologies on X. Define a function $f : (X, T) \rightarrow (Y,S)$ as $f(a) = a$, $f(b) = b$

Then f is a *NGR contra-continuous function* but $f^{-1}(B)$ is not a Neutrosophic closed set in (X,T).

Hence f is not a Neutrosophic *contra-continuous* function.

Theorem 3.3

Every NR closed sets is NGR closed set. But the converse is not true.

Proof :

Let A be *NR closed* sets in X and let $A \subseteq U$ and U is *Neutrosophic open* set in X.

We know that $A = Ncl(Nint(A))$ (By definition 2.12)

$\Rightarrow Ncl(Nint(A)) \subseteq U$

That is $NRcl(A) \subseteq U$

Therefore we have $NRcl(A) \subseteq U$,whenever $A \subseteq U$ and U is Neutrosophic open set in X .

Therefore by definition 2.14 , A is *NGR closed* set in X. Hence proved.

The converse of theorem 3.3 is not true is shown in example 3.4

Example 3.4

Let $X = \{a, b\}$ and where $A_1 = \{(0.4, 0.6, 0.5), (0.7, 0.3, 0.6)\}$,

$A_2 = \{(0.3, 0.6, 0.8), (0.6, 0.3, 0.6)\}$ and $\tau_N = \{0_N , A_1, A_2, 1_N \}$ is Neutrosophic topological space. Then $A_3 = \{(0.5, 0.7, 0.5), (0.9, 0.4, 0.5)\}$ is *NGR closed* set but not *NR closed* set.

Theorem 3.5

Let (X, T) and (Y, S) be any two Neutrosophic topological spaces.

If $f : (X, T) \rightarrow (Y, S)$ is a NR contra-continuous function then f is a NGR contra-continuous function.

Proof:

Let B be a *Neutrosophic open* set in (Y, S).

Since f is a *NR contra-continuous* function,

By definition 3.1(i) , $f^{-1}(B)$ is a *NR closed* set in (X, T).

Since by theorem 3.3, We know, Every *NR closed* set is a *NGR closed* set.

We get, $f^{-1}(B)$ is a *NGR closed* set in (X, T).

Hence by definition 3.1(ii) , f is a *NGR contra-continuous* function. Hence proved.

The converse of theorem 3.5 need not be true as shown in example 3.5.1 .

Example 3.5.1

Let $X = \{a, b\}$ and where $A = \{(0.5, 0.5, 0.5), (0.5, 0.5, 0.5)\}$ and $B = \{(0.4, 0.4, 0.4), (0.6, 0.6, 0.6)\}$ is Neutrosophic sets. Then the families $T = \{0_N , 1_N , A\}$ and $S = \{0_N , 1_N , B\}$are Neutrosophic topologies

on X. Define a function $f : (X, T) \to (Y, S)$ as $f(a) = a$, $f(b) = b$
Then f is a *NGR contra-continuous function* but $f^{-1}(B)$ is not a NR closed set in *(X,T)*. Hence f not a *NR contra-continuous* function.

Theorem 3.6
For any two Neutrosophic topological spaces (X, T) and (Y, S). If $f : (X, T) \to (Y, S)$ is a Strongly NGR contra-continuous function then f is a NGR contra-continuous function.
Proof:
Let B be a Neutrosophic open set in (Y, S).
We know, Every Neutrosophic open set is a *NGR open* set.
Now, B is a *NGR open* set in (Y, S).
Since f is a *Strongly NGR contra-continuous* function,
By definition 3.1(iii) , $f^{-1}(B)$ is a Neutrosophic closed set in (X, T).
Since every *Neutrosophic closed* set is a *NGR closed* set
$f^{-1}(B)$ is a *NGR closed* set in (X, T).
Hence by definition 3.1(ii) , f is a *NGR contra-continuous* function.
Hence proved.
The converse of theorem 3.6 need not be true as shown in example 3.6.1 .

Example 3.6.1
Let $X = \{a, b\}$ and where $A = \{(0.4, 0.4, 0.4), (0.3, 0.3, 0.3)\}$ and $B = \{(0.2, 0.2, 0.3), (0.8, 0.8, 0.7)\}$ is Neutrosophic sets. Then the families $T = \{0_N, 1_N, A\}$ and $S = \{0_N, 1_N, B\}$are Neutrosophic topologies on X. Define a function $f : (X, T) \to (Y, S)$ as $f(a) = a$, $f(b) = b$ .Then f is a *NGR contra-continuous function.* Let $C = \{(0.4, 0.4, 0.4), (0.6,0.6,0.6)\}$ be a NGR open in *(X,T)* set, but $f^{-1}(C)$ is not a Neutrosophic closed set in *(X,T).* Hence f is not a *Strongly NGR contra-continuous* function.

Theorem 3.7
For any two Neutrosophic topological spaces (X,T) and (Y,S). If $f : (X, T) \to (Y, S)$ is a Strongly NGR contra-continuous function then f is a Neutrosophic contra-continuous function.
Proof:
Let B be a Neutrosophic open set in (Y, S).
We know, Every Neutrosophic open set is a *NGR open* set.
Now, B is a *NGR open* set in (Y, S).
Since f is a *Strongly NGR contra-continuous* function,
By definition 3.1(iii) , $f^{-1}(B)$ is a Neutrosophic closed set in (X, T).
Hence by definition 2.17 (i), f is a *Neutrosophic contra-continuous* function.
Hence proved.

Theorem 3.8
Let (X,T),(Y,S) and (Z,R) be any three Neutrosophic topological spaces. If a function $f : (X, T) \to (Y, S)$ is strongly NGR continuous function and $g : (Y, S) \to (Z, R)$ is a NGR contra-continuous function then $g \circ f$ is a Neutrosophic contra-continuous function.
Proof:
Let B be a Neutrosophic open set in (Z, R).
Since g is a *NGR contra-continuous* function,
By definition 3.1(ii) , $g^{-1}(B)$ is *NGR closed* set in (Y, S).
Since f is *Strongly NGR continuous* function,
By definition 2.16(iii) , $f^{-1}(g^{-1}(B))$ is a Neutrosophic closed set in (X, T).
Hence by definition 2.17(i) , $g \circ f$ is a *Neutrosophic contra-continuous* function. Hence proved.

Theorem 3.9
Let (X,T),(Y,S) and (Z,R) be any three Neutrosophic topological spaces. If f is a NGR contra-continuous function and g is a Neutrosophic continuous function, then $g \circ f$ is a NGR contra-continuous function.
Proof:
Let B be a Neutrosophic open set in (Z, R).
Since g is a *Neutrosophic continuous* function,
By definition 2.15(i) , $g^{-1}(B)$ is Neutrosophic open set in (Y, S).
Since f is a *NGR contra-continuous* function,
By definition 3.1(ii), $f^{-1}(g^{-1}(B))$ is a *NGR closed* set in (X, T).
Hence by definition 4.1(ii), $g \circ f$ is a *NGR contra-continuous* function. Hence proved.

Theorem 3.10
Let (X,T),(Y,S) and (Z,R) be any three Neutrosophic topological spaces. If f is a NGR contra-continuous function and g is a Neutrosophic contra- continuous function, then $g \circ f$ is a NGR continuous function.
Proof:
Let B be a Neutrosophic open set in (Z, R).
Since g is a *Neutrosophic contra- continuous* function,
By definition 2.17(i) , $g^{-1}(B)$ is *Neutrosophic closed* set in (Y, S).
Since f is a *NGR contra-continuous* function,
By definition 3.1(ii) , $f^{-1}(g^{-1}(B))$ is a *NGR open* set in (X, T).
Hence by definition 3.1(i), $g \circ f$ is a *NGR continuous* function . Hence proved.

Theorem 3.11
Let (X,T),(Y,S) and (Z,R) be any three Neutrosophic topological spaces. If f is a NGR contra-irresolute function and g is a NGR contra-continuous function, then $g \circ f$ is a NGR continuous function.

Proof:
Let B be a Neutrosophic open set in (Z, R).
Since g is a *NGR contra -continuous* function,
By definition 3.1(ii) , $g^{-1}(B)$ is *NGR closed* set in (Y, S).
Since f is a *NGR contra-irresolute* function,
By definition 3.1(iv) , $f^{-1}(g^{-1}(B))$ is a *NGR open* set in (X, T).
Hence by definition 2.16(i), $g \circ f$ is a *NGR continuous* function. Hence proved.

Theorem 3.12
Let $(X,T),(Y,S)$ and (Z,R) be any three Neutrosophic topological spaces. If f is a NGR irresolute function and
g is a NGR contra-continuous function, then $g \circ f$ is a NGR contra- continuous function.
Proof:
Let B be a Neutrosophic open set in (Z, R).
Since g is a *NGR contra -continuous* function,
By definition 3.1(ii) , $g^{-1}(B)$ is *NGR closed* set in (Y, S).
Since f is a *NGR irresolute* function,
By definition 2.16(ii) , $f^{-1}(g^{-1}(B))$ is a *NGR closed* set in (X, T).
Hence by definition 3.1(ii) , $g \circ f$ is a *NGR contra-continuous* function. Hence proved.

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