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On Neutrosophic Relations in Group Theory

Majid Mohammed Abed[1,*], Dunia Alawi Jarwan[2], Marrwa Abdallah Salih[3]
[1]Department of mathematics, College of Education for Pure Sciences, University of Anbar, Iraq; majid_math@uoanbar.edu.iq
[2]Department of Applied mathematics, College Science, University of Anbar, Iraq; dunia.alswi@uoanbar.edu.iq
[3]D Department of mathematics College of Education for Pure Science, University of Tikrit, Iraq; marrwaabdallah1984@tu.edu.iq

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ABSTRACT: In this paper, we study neutrosophic of some triple relations or neutrosophic triple set (NTS) and related to the homomorphism groups. Various properties like equivalent relation, product, intersection, and the union are studied. We showed several equivalent relations in group theory with new examples about neutrosophic homomorphism. Finally, some definitions, examples, and other remarks of neutrosophic of these relations are given.

Keywords: Neutrosophic group, Neutrosophic set, Multiplication module, Relation, Homomorphism group.

1. INTRODUCTION

In 1980, Smarandache introduced new notion in mathematics is called neutrosophic theory. In neutrosophic, we consider the main principal which is named logic where approach to the truth T, indeterminacy I, and the falsity F. Indeterminacy deals with fuzzy theory and others theories. All facts about fuzzy set in [1]. W. B. Vasantha Kandasamy and Florentin Smarandache introduced more concepts like neutrosophic group, neutrosophic rings and neutrosophic semigroups. In [2] and [3], to find more results and information about neutrosophic relations. In [4], shwed some new results of neutrosophic multiplication module with some properties of neutrosophic set. Salama and Alblowi, 2012 [5], studied Neutrosophic set and neutrosophic topological space. Neutrosophic Groups and Subgroups in [6]. Soft neutrosophic semigroup and their generalization in [7]. Single valued neutrosophic mappings defined by single valued neutrosophic relations with applications in [8]. Neutrosophic BCK-algebra and Ω-BCK-algebra [9]. Some results of neutrosophic topological rings [10]. More details about the relations and some applications in [11-14] This paper is about to introduced neutrosophic of relations in group theory like homomorphism and equivalent relations such as reflexive, symmetric and transitive.

2. PRELIMINARIES

This section is about some of the various definitions, remarks and some basic properties which are used later in this notion. Also, we recall more facts related to neutrosophic sets [4, main paper].

Definition 2.1. [15] Let $X \neq \varphi$ be a set. Any set which is generated by X and I is called neutrosophic and denoted by X(I). Or let S be a collection of points with an element in S like b. A neutrosophic set B in S is truth function T_B, Indeterminacy function I_B and falsity function F_B.

$T_B(a)$, $I_B(a)$ and $F_B(a)$ are real and subsets of [0, 1] which written as:

$B= \{\prec b, (T_B(b), I_B(b), F_B(b)) \succ: b \in \Omega, T(b), I(b), F(b), \in [0, 1]\}$.

Remark 2.2. We can say:

$0 \leq T_B(b) + I_B(b) + F_B(b) \leq 3$.

Definition 2.3. Suppose that Ω be a universe. We define a neutrosophic triple set NTS(B) on Ω by the following:

$B=\{\prec b, (T_B^{1,2,3}(b), I_B^{1,2,3}(b), F_B^{1,2,3}(b)) \succ: b \in \Omega\}$ where $T_B^{1,2,3}(b):\Omega\to[0, 1]$, $I_B^{1,2,3}(b):\Omega\to[0, 1]$, $F^{1,2,3}{}_B(b):\Omega\to[0, 1]$.

Remark 2.4.

1) $0 \leq T_B^i(b) + I_B^i(b) + F_B^i(b) \ni i=1, 2, 3$ and $T_B^1(b) \leq T_B^2(b) \leq T_B^3(b)$, $b \in \Omega$.

2) NTS(Ω) refers to the set of all neutrosophic triple sets on Ω.

3) a) Assume that B and C belong to neutrosophic triple set of Ω. Then, the following statements are holds:

a) If $T_B^i(b)=1$ and $I_B^i(b)=0= F_B^i(b)$, $b \in \Omega$, so B named universal neutrosophic set Ω^*.

b) B is neutrosophic subset of C ($B\subseteq C$) when:

$T_B^i(b)\leq T_C^i(b)$, $I_B^i(b)\geq I_C^i(b)$ and $F_B^i(b)\geq F_C^i(b)$, $b \in \Omega$.

Definition 2.5. B^* is complement of B such that:

$B^*=\{\prec b, (F_B^{1,2,3}(b), I_B^{1,2,3}(b), T_B^{1,2,3}(b)) \succ: b \in \Omega\}$.

3. OPERATIONS OF NST(Ω)

In this section, we present more properties of neutrosophic set with several examples.

Remark 3.1.

a) Assume that B and C belong to neutrosophic triple set of Ω. So,

$B\cup C=\{\prec b, (T_{B\cup C}^{1,2,3}(b), I_{B\cup C}^{1,2,3}(b), F_{B\cup C}^{1,2,3}(b))\succ: b \in \Omega\}$.

$T_B^i(b) \vee T_C^i(b)= T_{B\cup C}^i(b)$

$I_B^i(b) \vee I_C^i(b)= I_{B\cup C}^i(b)$

$F_B^i(b) \vee F_C^i(b)= F_{B\cup C}^i(b)$

b) $B\cap C= \{\prec b, (T_{B\cap C}^{1,2,3}(b), I_{B\cap C}^{1,2,3}(b), F_{B\cap C}^{1,2,3}(b))\succ: b \in \Omega\}$.

$T_B^i(b) \wedge T_C^i(b)= T_{B\cap C}^i(b)$

$I_B^i(b) \vee I_C^i(b)= I_{B\cap C}^i(b)$

$F_B^i(b) \vee F_C^i(b)= F_{B\cap C}^i(b)$

c) $B+C= \{\prec b, (T_{B+C}^{1,2,3}(b), I_{B+C}^{1,2,3}(b), F_{B+C}^{1,2,3}(b))\succ: b \in \Omega\}$.

$T^i_B(b)+ T^i_C(b) - T^i_B(b). T^i_C(b) = T^i_{B+C}(b)$

$I^i_B(b). I^i_C(b)= I^i_{B+C}(b)$

$F^i_B(b). F^i_C(b)= F^i_{B+C}(b)$, $b \in\Omega$, i=1, 2, 3.

d) $B\times C=\{\prec b, (T^{1,2,3}_{B\times C}(b), I^{1,2,3}_{B\times C}(b), F^{1,2,3}_{B\times C}(b))\succ: b \in \Omega\}$.

Remark 3.2.

$T^i_{B\times C}(b)= T^i_B(b). T^i_C(b)$

$I^i_B(b)+ I^i_C(b)= I^i_{B\times C}(b)$

$F^i_B(b)+ F^i_C(b) - F^i_B(b). F^i_C(b = \mathbf{F^i_{B\times C}}(b)$, $b \in\Omega$, i=1, 2, 3.

Now we study some types of neutrosophic relations. We define and describe all properties of B×C as a cartesian product.

Definition 3.3.

Suppose that we have two non-zero of NTS(Ω) with i=1, 2, 3. So the cartesian product of B and C is named neutrosophic triple sets inside $\Omega\times\Omega$:

$B\times C=\{\prec(b, c), (T^i_{B\times C}(b, c), I^i_{B\times C}(b, c), F^i_{B\times C}(b, c))\succ: (b, c) \in \Omega\times\Omega\}$

where

$T_{B\times C}^i(b, c)=\min\{ T^i_B(b, c), T^i_C(b, c)\}$

$I^i_{B\times C}(b, c) =\max \{I^i_B(b, c), I^i_C(b, c)\}$

$F^i_{B\times C}(b, c)=\max\{ F^i_B(b, c), F^i_C(b, c)\}$, $b, c \in B\times C$, i=1, 2, 3.

Remark 3.4.

$B\times C=\{\prec(b, c), (T^i_{B\times C}(b, c), I^i_{B\times C}(b, c), F^i_{B\times C}(b, c))\succ: (b, c) \in \Omega\times\Omega\}$, i=1, 2, 3 with

$T^i_{B\times C}: \Omega\times\Omega\to [0, 1]$.

Note that we define a triple product of neutrosophic triple sets by the following:

Definition 3.5.

Let B, C and D are non-zero sets of neutrosophic triple sets: $i \in \{1, 2, 3\}$. The neutrosophic triple direct product of B, C and D in $\Omega\times\Omega\times\Omega$:

$B\times C\times D =\{\prec(b, c, d), (T^{1, 2, 3}_{B\times C\times D}(b, c, d), I^{1, 2, 3}_{B\times C\times D}(b, c, d), F^{1, 2, 3}_{B\times C\times D}(b, c, d))\succ: (b, c, d) \in \Omega\times\Omega_\times \Omega\}$, i=1, 2, 3 with

$T_{B\times C\times D}^i(b, c, d) =\min \{T^i_B(b, c, d), T^i_C(b, c, d), T^i_D(b, c, d)\}$

$I_{B\times C\times D}^i(b, c) =\max \{I^i_B(b, c, d), I^i_C(b, c, d), I^i_D(b, c, d)\}$

$F^i_{B\times C\times D}(b, c) =\max \{F^i_B(b, c, d), F^i_C(b, c, d), F^i_D(b, c, d)\}$, $b, c \in B\times C$, i=1, 2, 3.

Definition 3.6.

Let $B, C, D \in NTS(\Omega)$ and let R_1, R_2 and R_3 be three neutrosophic triple relations from $(B\times C) \to D$. Then we define $(R_1\cup R_2)\cup R_3$, $(R_1\cap R_2)\cap R_3$, $(R_1+R_2) +R_3$ and $(R_1\times R_2)\times R_3$ by the following:

$(R_1\cup R_2)\cup R_3=\{\prec((b, c), d), T^{1, 2, 3}_{(R1\cup R2)\cup R3}((b, c), d), I^{1, 2, 3}_{(R1\cup R2)\cup R3}((b, c), d), F^{1, 2, 3}_{(R1\cup R2)\cup R3}((b, c), d)\succ: ((b, c), d) \in \Omega\}$.

Remark 3.7.

$T^i_{(R1\cup R2)\cup R3}((b, c), d) =T^i_{R1\cup R2}(b, c) \vee T^i_{R3}(c)$,

$I^i_{(R1\cup R2)\cup R3}((b, c), d) =I^i_{R1\cup R2}(b, c) \wedge T^i_{R3}(c)$,

$F^i_{(R1\cup R2)\cup R3}((b, c), d) =F^i_{R1\cup R2}(b, c) \wedge F^i_{R3}(c)$, for all (b, c), d is belonging to Ω, i=1, 2. 3.

$(R_1\cap R_2)\cap R_3=\{\prec((b, c), d), T^{1, 2, 3}_{(R1\cap R2)\cup R3}((b, c), d), I^{1, 2, 3}_{(R1\cap R2)\cap R3}((b, c), d)$,

$F^{1, 2, 3}_{(R1\cap R2)\cap R3}((b, c), d)\succ: ((b, c), d) \in \Omega\}$.

Remark 3.8.

$T^i_{(R1\cap R2)\cap R3}((b, c), d) = T^i_{R1\cap R2}(b, c) \wedge T^i_{R3}(c)$,
$I^i_{(R1\cap R2)\cap R3}((b, c), d) = I^i_{R1\cap R2}(b, c) \vee T^i_{R3}(c)$,
$F^i_{(R1\cap R2)\cap R3}((b, c), d) = {}^i F_{R1\cap R2}(b, c) \vee F^i_{R3}(c)$, for all (b, c), d is belonging to Ω, i=1, 2. 3.
$(R_1+R_2)+R_3=\{\prec((b, c), d), T^{1, 2, 3}_{(R1+R2)+R3}((b, c), d), I^{1, 2, 3}_{(R1+R2)+R3}((b, c), d), F^{1, 2, 3}_{(R1+R2)+R3}((b, c), d) \succ: ((b, c), d) \in \Omega\}$.
Remark 3.9.
$T^i_{(R1+R2)+R3}((b, c), d) = T^i_{R1+R2}(b, c) - T^i_{R3}(c)$,
$I^i_{(R1+R2)+R3}((b, c), d) = I^i_{R1+R2}(b, c).\ T^i_{R3}(c)$,
$F^i_{(R1+R2)+R3}((b, c), d) = F^i_{R1+R2}(b, c).\ F^i_{R3}(c)$, for all (b, c), d is belonging to Ω, i=1, 2. 3.

$(R_1\times R_2)\times R_3=\{\prec((b, c), d), T^{1, 2, 3}_{(R1\times R2)\times R3}((b, c), d), I^{1, 2, 3}_{(R1\times R2)\times R3}((b, c), d), F^{1, 2, 3}_{(R1\times R2)\times R3}((b, c), d) \succ: ((b, c), d) \in \Omega\}$.
Remark 3.10.
$T^i_{(R1\times R2)\times R3}((b, c), d) = T^i_{R1\times R2}(b, c).\ T^i_{R3}(c)$,
$I^i_{(R1\times R2)\times R3}((b, c), d) = I^i_{R1\times R2}(b, c) - I^i_{R3}(c)$,
$F^i_{(R1\times R2)\times R3}((b, c), d) = F^i_{R1\times R2}(b, c) - F^i_{R3}(c)$, for all (b, c), d is belonging to Ω, i=1, 2. 3.

Note that if $\phi=S_1, S_2, S_3$ in neutrosophic triple sets of Ω, so any two neutrosophic triple sets under composition. Suppose that $R_1(S_1\rightarrow S_2)$ and $R_2(S_2\rightarrow S_3)$ is a two neutrosophic, we can define $R_2\circ R_1$ and it is neutrosophic triple relation from S_1 to S_3:
$R_2\circ R_2=\{<(a,c), (T^{1,2,3}_{R2\circ R2}(a, c), (I^1_{R2\circ R2}(a, c), I^{1,2,3}_{R2\circ R2}(a, c), (F^{1,2,3}_{R2\circ R2}(a, c)))>: a, c \in\Omega\}$.
Remark 3.11.
$T^j_{R2\circ R2}(a, c)=\vee_y\{T^j_{R1}(a, b) \wedge T^j_{R2}(b, c)\}$
$I^j_{R2\circ R2}(a, c)=\vee_y\{I^j_{R1}(a, b) \vee I^j_{R2}(b, c)\}$
$F^j_{R2\circ R2}(a, c)=\vee_y\{F^j_{R1}(a, b) \vee F^j_{R2}(b, c)\}$ for all $(a, c) \in \Omega \times \Omega$, $y \in \Omega$, i=1, 2, 3.

Neutrosophic equivalent relation:
1. $T^j_{R1}(a, a)=1$, $I^j_{R1}(a, a)=0$ and $F^j_{R1}(a, a)=0$, a belongs to Ω, then this relation is reflexive.
2. If $T^j_{R1}(a, b)= T^j_{R1}(b, a)$, $I^j_{R1}(a, b)=I^j_{R1}(b, a)$ and $F^j_{R1}(a, b)=F^j_{R1}(b, a)$ $\forall$ a, b $\in \Omega$, then this relation R is symmetric.
3. If $R\circ R\subseteq R$, then R is transitive.
4. If R satisfies (1), (2) and (3), then R is called neutrosophic triple equivalence.
5. If R=R∪R2∪R3, then R is transitive closure of neutrosophic triple relation.
Definition 3.12.
Let R be a neutrosophic triple relation ($R: S_1\rightarrow S_2$). So, the inverse neutrosophic triple relation (INT) is R^{-1}:
$R^{-1}= \{<(a, b), (T^j_{R^{-1}}(a, b), I^j_{R^{-1}}(a, b), F^j_{R^{-1}}(a, b): (a, b) \in \Omega \times \Omega\}$.
Remark 3.13.
$T^j_{R^{-1}}(a, b) = T^j_R(b, a)$
$I^j_{R^{-1}}(a, b)) = I^j_R(b, a)$
$F^j_{R^{-1}}(a, b)) = F^j_R(b, a)$, j= 1, 2, 3.

4. NEUTROSOPHIC DOMAIN AND THE CODOMAIN (NCOD)b

Let S_1 and S_2 be two sets with neutrosophich trible relation R has order pair (a, b). So the neutrosophic domain of R (NDR) is:
$NDR=\{\prec a :(a, b), T^{1, 2, 3}_D(a, b), I^{1, 2, 3}_D(a, b), F^{1, 2, 3}_D(a, b)) \succ: (a, b) \in \Omega\}$.
Also, we can present neutrosophic of the codomain (CD) by the following:
$NCDR=\{\prec a :(b, a), T^{1, 2, 3}_{CD}(b, a), I^{1, 2, 3}_{CD}(b, a), F^{1, 2, 3}_{CD}(b, a)) \succ: (b, a) \in \Omega\}$.
Example 4.1.
Let S_1={1, 2, 9} and S_2={1, 3, 7}:
1) If neutrosophic triple relation R is NR={(1, 1), (3, 3)}, then NDR={1, 3} and NCODR={1, 3}.
2) If R={(1, 3), (1, 7), (2, 3), (2, 7)}, then NDR={1, 2} and NCODR={3, 7}.
3) If R={(2, 1), (9, 1), (9, 3), (9, 7)}, then NDR={2, 9} and NCODR={1, 3, 7}.
Definition 4.2.
The neutrosophic triple identity relation on S is $\{(a, a):a\in\Omega\}$ and:
$NID = =\{\prec a :(a, a), T^{1, 2, 3}_{NID}(a, a), I^{1, 2, 3}_{NID}(a, a), F^{1, 2, 3}_{NID}(a, a)) \succ: (a, a) \in \Omega\}$.
Example 4.3.

The neutrosophic triple empty set is the subset itself. It is clearly neutrosophic triple irreflexive not neutrosophic triple reflexive.

Example 4.4.

Consider the neutrosophic triple relation R on S={1, 2, 3, 4} and defined by:
R={(1, 1), (2, 3), (2, 4), (3, 3), (3, 4)}. Note that (2, 2) ∉ R and (1, 1) ∈ R, so the neutrosophic triple relation is neither reflexive nor irreflexive. Also, we have (2, 3) ∈ R but (3, 2) ∉ R, then R is not neutrosophic triple relation symmetric. On the other hand, if we have a≠b, then only one of the following true:
(a, b) ∉ R, (b, a) ∉ R, (a, b) ∈R or (b, a) ∈ R.

5. NEUTROSOPHIC HOMOMORPHISM GROUP

Definition 5.1.

Let (G, *) be a group. If $\prec G\cup I \succ$={a+bI}: a, b ∈ G}, then ($\prec G\cup I \succ$, *) is called neutrosophic group, where G, I are generators of NG.

Definition 5.2.

The neutrosophic homomorphism f (denote by Nf) between two groups G_1 and G_2 is:
$Nf:NG_1\rightarrow NG_2 \ni N(f(a*b))=N(f(a)*N(f(b))$

Definition 5.3.

The neutrosophic triple homomorphism can define by:
$N(f(a*b))=\{<a: (a*b), (T^{1,2,3}{}_f\,(a, b), I^{1,2,3}{}_f\,(a, b), F^{1,2,3}{}_f(a, b)>: a, b \in G\}$ where:
$T^i{}_f(a, b)=T^i{}_f(a)*T^i{}_f(b)$,
$I^i{}_f(a, b)=I^i{}_f(a)*I^i{}_f(b)$,
$F^i{}_f(a, b)=F^i{}_f(a)*F^i{}_f(b)$, i=1, 2, 3.

Example 5.4.

Let $NG_1=(\prec G_1\cup I \succ)$ and $NG_2=(\prec G_2\cup I \succ)$ be two neutrosophic groups with neutrosophic identity elements Ne_1 and Ne_2, respectively. Then
$Nf: (G_1\cup I \succ) \rightarrow(G_2\cup I)$ define by:

$$N(f(a*b))=Ne_2$$
$$=Ne_2 \circ Ne_2$$
$$=N(f(a))\circ N(f(b)).$$

Hence the neutrosophic triple identity homomorphism is:
$N(f(a*b))= T^{1,2,3}{}_f(a*b)$:
$T^i{}_f(a*b)= T^i{}_f(a)\circ T^i{}_f(b)$
$=Ne_2\circ Ne_2$
$=Ne_2$,
$I^i{}_f(a*b)= I^i{}_f(a)\circ I^i{}_f(b)$
$=Ne_2\circ Ne_2$
$=Ne_2$,
$F^i{}_f(a*b)= F^i{}_f(a)\circ F^i{}_f(b)$
$=Ne_2\circ Ne_2$
$=Ne_2$.

Some Applications :

Proposition 5.5.

Let $(G_1, +) \rightarrow (G_2-\{0\}, .)$ be a homomorphism group and let $f(a)=2^a$. Then f is a neutrosophic triple homomorphism.

Proof: Let $N(f(a))=2^a$. Then
$T^1{}_f(a+b)= T^{1,2.3}{}_f\,(a).\ T^{1,2.3}{}_f\,(b)=2^{a+b}=2^a.2^b$,
$I_f(a+b)= I^{1,2.3}{}_f\,(a).\ I^{1,2.3}{}_f\,(b)=2^{a+b}=2^a.2^b$, and
$F_f(a+b)= F^{1,2.3}{}_f\,(a).\ F^{1,2.3}{}_f\,(b)=2^{a+b}=2^a.2^b$.
Thus, Then f is a neutrosophic triple homomorphism.

Proposition 5.6.

Let (Z, +) be a group of integer numbers and let $(Z_n, +_n)$ be the group of integer numbers modulo n. If f: $(Z, +) \rightarrow (Z_n, +_n)$ be a homomorphism groups defined by f(a)=[a], then f is neutrosophic triple homomorphism.

Proof: Clear that
$T_f(a, b)=\{\prec a ,(a, b), T^{1, 2, 3}{}_f\,(a, b), I^{1, 2, 3}{}_f\,(b, a), F^{1, 2, 3}{}_f\,(b, a)) \succ: (b, a) \in \Omega\}=$

$[a+b]= T^{1, 2, 3}{}_f(a, b)= T^{1, 2, 3}{}_f(a)+ T^{1, 2, 3}{}_f(b)$,
$[a+b]= I^{1, 2, 3}{}_f(a, b)= I^{1, 2, 3}{}_f(a)+ I^{1, 2, 3}{}_f(b)$,
$[a+b]= F^{1, 2, 3}{}_f(a, b)= F^{1, 2, 3}{}_f(a)+ F^{1, 2, 3}{}_f(b)$.

Proposition 5.7.

The pair (hom G, ∘) where (∘) denotes functional composition, forms a semigroup with identity.

Proof: $f\circ g=\{\prec(a, b), (T^{1,2,3}{}_{f\circ g}(a, b)), (I^{1,2,3}{}_{f\circ g}(a, b)), (F^{1,2,3}{}_{f\circ g}(a, b))\succ: a, b \in G\}$, where
$\{(T^j{}_{f\circ g}(a, b))=\{ (T^j{}_{f\circ g}(a)* (T^j{}_{f\circ g}(a)\}$,
$\{(I^j{}_{f\circ g}(a, b))=\{ (I^j{}_{f\circ g}(a)* (I^j{}_{f\circ g}(a)\}$,
$\{(F^j{}_{f\circ g}(a, b))=\{ (F^j{}_{f\circ g}(a)* (F^j{}_{f\circ g}(a)\}$

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