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TOTALLY NANO Sg CONTINUOUS FUNCTIONS AND SLIGHTLY NANO Sg CONTINUOUS FUNCTIONS IN NANO TOPOLOGICAL SPACES

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ABSTRACT

Semi generalized closed sets plays important role generalized topological spaces .In this paper we studied about Totally Nano sg continuous functions and slightly Nano sg continuous functions in Nano topological spaces

Keywords: *Nano Topological spaces, nano sg-closed set, nano sg-open set, Totally Nano sg continuous functions and slightly Nano-sg continuous functions.*

1. INTRODUCTION

The concept of nano topology was introduced by Lellis Thivagar [7] which was defined in terms of approximations and boundary region of a subset of an universe using an equivalence relation on it. He also established the weak forms of nano open sets namely nano open sets, nano semi open sets and nano pre open sets in a nano topological space. nano sg closed introduced by K.Bhuvaneswari [1] *et al.* .Since the advent of these notions several research papers with interesting results in different respects came to existence. In this paper we studied about Totally Nano sg continuity and Slightly Nano sg continuous functions using Nano sg closed sets in nano topological spaces

2. PRELIMINARIES

Definition 2.1: Let U be a non-empty finite set of objects called the universe and R be an equivalence relation on U named as the indiscernibility relation. Elements belonging to the same equivalence class are said to be indiscernible with one another. The pair (U, R) is said to be the approximation space. Let $X \subseteq U$.

(i) The lower approximation of X with respect to R is the set of all objects, which can be for certain classified as X with respect to R and it is denoted by $L_R(X)$. That is,
$L_R(X) = \bigcup_{x \in U}\{R(x): R(x) \subseteq X\}$where R(x) denotes the equivalence class determined by X.

(ii) The upper approximation of X with respect to R is the set of all objects, which can be possibly classified as X with respect to R and it is denoted by $U_R(X)$.That is,
$U_R(X)= \bigcup_{x \in U}\{R(x): R(x) \cap X \neq \phi\}$

(iii) The boundary region of X with respect to R is the set of all objects, which can be neither in nor as not-X with respect to R and it is denoted by $B_R(X)$.
That is, $B_R(X) = U_R(X) - L_R(X)$

Definition 2.2: If (U, R) is an approximation space and $X, Y \subseteq U$, then

(i) $L_R(X) \subseteq X \subseteq U_R(X)$
(ii) $L_R(\phi) = U_R(\phi) = \phi$, $L_R(U) = U_R(U) = U$,
(iii) $U_R(X \cup Y)= U_R(X) \cup U_R(Y)$

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(iv) $U_R(X\cup Y) \subseteq U_R(X) \cap U_R(Y)$
(v) $L_R(X\cup Y) \supseteq L_R(X)\cup L_R(Y)$
(vi) $L_R(X \cap Y)= L_R(X) \cap L_R(Y)$
(vii) $L_R(X)\subseteq L_R(Y)$ and $U_R(X)\subseteq U_R(Y)$ whenever $X\subseteq Y$
(viii) $U_R(X^c)= [L_R(X)]^C$ and $L_R(X^c)=[U_R(X)]^C$
(ix) $U_R(U_R(X)) = L_R(U_R(X)) = U_R(X)$
(x) $L_R(L_R(X)) = U_R(L_R(X))=L_R(X)$

Definition 2.3: Let U be an universe, R be an equivalence relation on U and $\tau_R(X) = \{U, \phi, L_R(X), U_R(X), B_R(X)\}$ where $X \subseteq U$. $\tau_R(X)$ satisfies the following axioms
(i) $U\phi \in \tau_R(X)$
(ii) The union of the elements of any sub-collection of $\tau_R(X)$ is in$\tau_R(X)$
(iii) The intersection of the elements of any finite sub collection of $\tau_R(X)$ is in$\tau_R(X)$.
Then $\tau_R(X)$ is called the nano topology on U with respect to X.

The space $(U, \tau_R(X))$ is the nano topological space. The elements of $\tau_R(X)$ are called nano open sets.

Definition 2.4: A subset A of $(U, \tau_R(X))$ is called if
(i) Nano semi-open if $A \subseteq Ncl(Nint(A))$.[6] Nano semi closed if $Ncl(Nint(A)) \subseteq A$
(ii) Nano-regular open set if A=Ncl(Nint(A)). [7] Nano-regular closed set if Ncl(Nint(A)) = A
(iii) Nano semi-generalized closed [1](briefly Nano-sg-closed) set if $Nscl(A) \subseteq M$ whenever $A \subseteq M$and M is semi-open in U. The complement of nano sg-closed set is called nano sg-open

Definition 2.5: A Nano topological space U is said to be connected if U cannot be expressed as the union two disjoint non empty nano open sets in U.

Definition 2.6: A Nano topological space U is said to be Nano-sg connected if U cannot be expressed as a disjoint union of two non empty Nano-sg open sets

Definition 2.7: A space $(U, \boldsymbol{\tau_R(X)})$ is called a locally indiscrete space if every nano open set of U is nano closed in U.

Definition 2.8: Every nano open set is Nano-sg open and every nano closed set is Nano-sg closed.

3. TOTALLY NANO-SG-CONTINUOUS FUNCTIONS

Definition 3.1: A function f: $(U, \boldsymbol{\tau_R(X)}) \to (V, \boldsymbol{\tau_R'(Y)})$ is called totally nano continuous if the inverse image of every nano open subset of $(V, \boldsymbol{\tau_R'(Y)})$ is a nano clopen subset of $(U, \boldsymbol{\tau_R(X)})$.

Definition 3.2: A function f : $(U, \boldsymbol{\tau_R(X)}) \to (V, \boldsymbol{\tau_R'(Y)})$ is said to be totally Nano-sg-continuous,if the inverse image of every nano open subset of $(V, \boldsymbol{\tau_R'(Y)})$ is a Nano-sg clopen subset of $(U, \boldsymbol{\tau_R(X)})$.

Example 3.3:
U ={a, b, c, d},with U/R ={{a},{c}, {b, d}} and

X = {a, b} Then the nano topology, $\tau_R(X)$ = {U, ϕ, {a}, {a, b, d}, {b, d}}.

Nano sg-open sets are
{U, ϕ , {a, c, d}, {a, b, d}, {a, b, c},{b, c, d}, {b, d}, {a, d}, {a, b}, {a, c}, {a}, {b}, {d}}

Nano sg-closed sets are
{U, ϕ , {b}, {c}, {d},{a}, {a, c}, {b, c}, {c, d}, {b, d}, {b, c, d}, {a, c, d}, {a, b, c}}

V= {a, b, c, d} With V/R = {{a},{b, c} ,{d}}
Y = {a, c} Then the nano topology $\tau_R'(Y)$ = {V, ϕ, {a}, {b, c}, {a, b, c}}.

The the identity function f: $(U,\tau_R(X))\to(V, \tau_R'(Y))$
Then $f^{-1}(V)$= V,$f^{-1}(\phi)=\phi$, $f^{-1}(\{a\})=\{a\}$, $f^{-1}\{b, c\}=\{b, c\}$,$f^{-1}(\{a, b, c\})=\{a, b, c\}$
Thus the inverse image of every nano open set in V is nano sg-clopen in U.

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Theorem 3.4: Every totally nano continuous functions is totally Nano-sg continuous.

Proof: Let N be an Nano open set of (V,τ_R'(Y)). Since f is totally nano continuous functions, $f^{-1}(V)$ is both Nano open and Nano closed in (U, τ_R(X)). Since every Nano open set is Nano-sg open and every Nano closed set is Nano-sg closed. $f^{-1}(V)$ is both Nano-sg open and Nano-sg closed in (U, τ_R(X)). Therefore f is totally Nano-sg continuous.

Remark 3.5: The converse of the above theorem need not be true.

Example 3.6:
Let U= {1, 2, 3, 4} with U/R = {{1}, {3}, {2, 4}}.
Let X= {1, 2}⊆ U. Then τ_R(X) = {U, ϕ, {1}, {1, 2, 4}, {2, 4}}.

Nano sg-open sets are
NSGO={U, ϕ, {1}, {2},{4},{2, 4}, {1, 4}, {1, 2},{1, 3},{1, 3, 4}, {1, 2, 4}, {1, 2, 3},{2, 3, 4}}.

Let V = {1, 2, 3, 4} with V/R= {{1, 2}, {3}, {4}}.

Let Y= {1, 4}⊆ V. Then τ_R' (Y) = {U, ϕ, {4},{1, 2, 4}, {1,2}}.
Then the identity function f: (U,τ_R(X))→(V, τ_R' (Y)) is totally Nano-sg continuous but not totally nano continuous function

Theorem 3.7: If f is a totally Nano-sg-continuous function from a Nano-sg-connected space U onto any space V, then V is an indiscrete space.

Proof: Suppose that V is not indiscrete. Let A be a proper non-empty nano open subset of V. Then f^{-1}(A) is a proper non-empty Nano-sg-clopen subset of (U, $\boldsymbol{\tau_R(X)}$) which is a contradiction to the fact that U is Nano-sg-connected.

Definition 3.8: A space U is said to be Nano-sg-T_2 if for any pair of distinct points x, y of U, there exist disjoint Nano-sg-open sets M and N such that x ∈ M and y ∈ N.

Lemma 3.9: The Nano-sg closure of every Nano-sg-open set is Nano-sg-open.

Proof: Every nano regular open set is nano open and every nano open set is Nano-sg-open. Thus, every nano regular closed set is Nano - sgclosed. Now let A be any Nano-sg-open set. There exists an nano open set M such that M ⊂ A ⊂ cl(M). Hence, we have M ⊂ Nano-sg-cl(M) ⊂ Nano-sg-cl(A) ⊂ Nano-sg-cl(cl(M))=cl(M) since cl(M) is nano regular closed. Therefore, Nano-sg-cl(A) is Nano-sg-open.

Theorem 3.10: A space U is Nano-sg-T_2 if and only if for any pair of distinct points x, y of U there exist Nano-sg-open sets M and N such that x ∈ M, and y ∈ N and Nano-sgcl(M) ∩ Nano-sgcl(N) = ϕ.

Proof: Necessity: Suppose that U is Nano-sg-T_2. Let x and y be distinct points of U. There exist Nano-sg-open sets U and V such that x ∈ M, y ∈ N and M ∩ N = ϕ. Hence Nano-sgcl(M) ∩ Nano-sgcl(N) = ϕ and by Lemma 3.9, Nano-sgcl(M) is Nano-sg-open. Therefore, we obtain Nano-sgcl(U) ∩ Nano-sgcl(N) = ϕ.

Sufficiency: This is obvious.

Theorem 3.11: If f : (U, $\boldsymbol{\tau_R(X)}$) → (V, $\boldsymbol{\tau_R'(Y)}$) is a totally Nano-sg continuous injection and V is T_0 then U is Nano-sg-T_2.

Proof: Let x and y be any pair of distinct points of U. Then f(x) ≠ f(y). Since V is T_0, there exists an open set M containing say, f(x) but not f(y). Then x∈ f^{-1}(M) and y∉ f^{-1}(M). Since f is totally Nano-sg-continuous, f^{-1}(M) is a Nano-sg-clopen subset of U. Also, x ∈ f^{-1}(M) and y∈ U – f^{-1}(M). By Theorem 3.10, it follows that U is Nano-sg-T_2.

Theorem 3.12: Let f : (U, $\boldsymbol{\tau_R(X)}$) → (V, $\boldsymbol{\tau_R'(Y)}$) be a totally Nano-sg-continuous function and V be a T_1-space. If A is a non-empty Nano-sg-connected subset of U, then f(A) is a single point.

Definition 3.13: Let (U, $\boldsymbol{\tau_R(X)}$) be a Nano topological space. Then the set of all points y in U such that x and y cannot be separated by a Nano-sg-separation of U is said to be the quasi Nano-sg-component of U.

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Theorem 3.14: Let f: (U, $\boldsymbol{\tau_R(X)}$) → (V, $\boldsymbol{\tau_R'(Y)}$)be a totally Nano-sg-continuous function from a nano topological space (U, $\boldsymbol{\tau_R(X)}$) into a T_1-space V. Then f is constant on each quasi Nano-sg-component of U.

Proof: Let x and y be two points of U that lie in the same quasi-Nano-sg-component of U. Assume that f(x) = $\alpha \neq \beta$ = f(y). Since V is T_1, {α} is nano closed in V and so V −{α} is an nano open set. Since f is totally Nano-sg-continuous, therefore $f^{-1}(\{\alpha\})$ and $f^{-1}(V-\{\alpha\})$ are disjoint Nano-sg-clopen subsets of U. Further, x ∈ $f^{-1}(\{\alpha\})$ and y ∈ $f^{-1}(V-\{\alpha\})$, which is a contradiction in view of the fact that y belongs to the quasi Nano-sg component of x and hence y must belong to every Nano-sg-open set containing x.

4. SLIGHTLY NANO-SG CONTINUOUS FUNCTIONS

Definition 4.1: A function f: (U, $\tau_R(X)$) → (V, $\tau_R'(Y)$) is called slightly nano continuous if the inverse image of every nano clopen set in (V, $\tau_R'(Y)$) is open in (U, $\tau_R(X)$).

Definition 4.2: A function f : (U, $\tau_R(X)$) → (V, $\tau_R'(Y)$) is said to be slightly Nano-sg continuous if the inverse image of every clopen set in (V, $\tau_R'(Y)$) is Nano-sg-open in (U, $\tau_R(X)$).

Example 4.3:
Let U= V ={1, 2, 3, 4,5} with U/R={{1},{2,4},{3,5}}.

Let X={1, 2}⊆ U.
Then $\tau_R(X)$ = {U, ϕ, {1}, {1, 2, 4},{2, 4}}.

Nano sg-open sets are
NSGO(U)={U, ϕ {1},{2},{3},{1,2},{1,3},{1,4}{1,5},{2,3},{2,4},{2,5},{3,4},{3,5},{4,5},
{1,2,3},{1,2,4}, {1,2,5},{1,3,4},{1,3,5},{1,4,5},{2,4,5},{3,4,5},{1,2,3,4},{1,2,3,5},{1,2,4,5}, {1,3,4,5},{2,3,4,5}}

V ={1, 2, 3, 4,5} with V/R={{1},{2,4},{3,5}}.

Y= {1, 5}⊆ V
Then $\tau_R'(Y)$= {V, ϕ, {1}, {1, 3, 5}, {3,5}}.
f : (U, $\tau_R(X)$) → (V, $\tau_R'(Y)$) is said to be slightly Nano-sg continuous
Then the identity function f: (U,$\tau_R(X)$→(V, $\tau_R'(Y)$)
Then $f^{-1}(V)$ = U, $f^{-1}(\phi)=\phi$, $f^{-1}(\{1\})=\{1\}$, $f^{-1}\{3, 5\}=\{3, 5\}$,$f^{-1}(\{2,4\})=\{2,4\}$, $f^{-1}(\{1, 3, 5\})$ ={1, 3, 5}, $f^{-1}(\{1,2,4\})=\{1,2,4\}$, $f^{-1}(\{2,3,4,5\})$= {2,3,4,5}

Theorem 4.4: For a function f : (U, $\tau_R(X)$) → (V, $\tau_R'(Y)$), the following statements are equivalent.
(i) f is slightly Nano-sg-continuous.
(ii) The inverse image of every nano clopen set N of V is Nano-sg- open in U.
(iii) The inverse image of every nano clopen set N of V is Nano-sg- closed in U.
(iv) The inverse image of every nano clopen set N of V is Nano-sg- clopen in U.

Proof:
(i)⇒(ii): Follows from the Definition 4.4.

(ii)⇒(iii): Let N be a nano clopen set in V which implies N^C is clopen in V. By (ii), f^{-1} (N^C)=$(f-1(N))^C$ is Nano-sg-open in U. Therefore, f^{-1}(N) is Nano-sg-closed in U.

(iii)⇒(iv): By (ii) and (iii), f^{-1}(N) is Nano-sg-clopen in U.

(iv)⇒(i): Let N be a nano clopen set in V containing $f(x)$, by (iv), f^{-1}(N) is Nano-sg clopen in U Take $U = f^{-1}$(N), then f(M) ⊆ N. Hence, f is slightly Nano-sg-continuous.

Theorem 4.5: Every slightly continuous function is slightly Nano-sg- continuous.

Proof: Let f: (U, $\tau_R(X)$) → (V, $\tau_R'(Y)$) be a Nano-sg continuous function. Let N be a nano clopen set in V. Then, f^{-1}(N) is Nano-sg-open and Nano-sg-closed in U. Hence, f is slightly Nano-sg-continuous.

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Remark 4.6: The converse of the above theorem need not be true as can be seen from the following example

Example 4.7:
Let U= {1, 2, 3, 4} with U/R= {{1}, {2, 3}, {4}}.
Let X ={1, 3}⊆ U. Then τ_R(X) = {U, ϕ,{1}, {2, 3}, {1, 2, 3}}.
Nano sg-open sets are
NSGO ={U, ϕ, {1}, {2}, {3},{2, 3}, {1, 4}, {1, 2}, {1, 3}, {2, 3, 4},{1, 3, 4},{1, 2, 4},{1, 2, 3}}.
Let V = {1, 2, 3, 4} with V /R= {{1},{2, 3},{4}}.
Let Y = {1, 4}⊆ U. Then $\tau_R{}'$(Y) ={V, ϕ ,{1,4}}.
f: (U, τ_R(X)) → (V, $\tau_R{}'$(Y)) under the condition f(1) = 2, f(2) = 1, f(3) = 4, f(4) = 3 is slightly Nano-sg- continuous but not slightly continuous function.

Theorem 4.8: Every contra Nano-sg continuous function is slightly Nano-sg continuous.

Proof: Let f: (U, τ_R(X)) → (V, $\tau_R{}'$(Y)) be a contra Nano-sg continuous function. Let N be a clopen set in V. Then, f^{-1}(N) is Nano-sg- open in U. Hence, f is slightly Nano-sg continuous.

Theorem 4.9: If the function f: (U, τ_R(X)) → (V,$\tau_R{}'$(Y)) is slightly Nano-sg continuous and (U, τ_R(X)) is Nano-sg$T_{1/2}$ space, then f is slightly continuous.

Proof: Let N be a nano clopen set in Z. Since g is slightly Nano-sg- continuous, f^{-1}(N) is Nano-sg open in U . Since U is Nano-sg$T_{1/2}$ space, f^{-1}(N) is nano open in U. Hence f is slightly continuous.

Theorem 4.19: Let f: (U, τ_R(X)) → (V, $\tau_R{}'$(Y)) and g: (V, $\tau_R{}'$(Y)) → (W, $\tau_R{}''$(Z)) be functions. If f is surjective and pre Nano-sg-open and ($g \circ f$): (U, τ_R(X)) → (W, $\tau_R{}''$(Z)) is slightly Nano-sg continuous, then g is slightly Nano-sg-continuous.

Proof: Let N be a Nano clopen set in (W, $\tau_R{}''$(Z)). Since ($g \circ f$): (U, τ_R(X)) → (W, $\tau_R{}''$(Z)) is slightly Nano-sg -continuous, f^{-1}(g^{-1}(N)) is Nano-sg-open in U. Since, f is surjective and pre Nano-sg -open (f^{-1}(g^{-1} (N))) =g^{-1} (N) is Nano-sg -open. Hence g is slightly Nano-sg-continuous.

Theorem 4.10: Let f : (U, τ_R(X)) → (V, $\tau_R{}'$(Y))and g: (V, $\tau_R{}'$(Y))→ (W, $\tau_R{}''$(Z)) be functions. If f is surjective and pre Nano-sg-open and Nano-sg -irresolute, then ($g \circ f$): (U, τ_R(X)) → (W, $\tau_R{}''$(Z)) is slightly Nano-sg continuous if and only if g is slightly Nano-sg continuous.

Proof: Let N be a Nano clopen set in (W, $\tau_R{}''$(Z)). Since ($g \circ f$): (U, τ_R(X)) → (W, $\tau_R{}''$(Z)) is slightly Nano-sg continuous, f^{-1}(g^{-1}(N)) is Nano-sg-open in U. Since, f is surjective and pre Nano-sg open (f^{-1} (g^{-1} (N))) = g^{-1}(N)is Nano-sg open in V. Hence g is slightly Nano-sg-continuous.

Conversely, let g is slightly Nano-sg continuous. Let N be a Nano clopen set in (W, $\tau_R{}''$(Z)), then g is Nano-sg open in V . Since, f is Nano-sg irresolute, f^{-1}(g^{-1}(N)) is Nano-sg-open in U. ($g \circ f$): (U, τ_R(X)) → (W, $\tau_R{}''$(Z)) is slightly Nanosg-continuous.

Theorem 4.11: If f is slightly Nano-sg continuous from a Nano-sg- connected space (U,τ_R(X) onto a space (V, $\tau_R{}'$(Y)) then V is not a discrete space.

Proof: Suppose that V is a discrete space. Let N be a proper non empty nano open subset of V. Since, f is slightly Nano-sg - continuous, f^{-1}(N) is a proper non empty Nano-sg clopen subset of U which is a contradiction to the fact that U is Nano-sg-connected.

Theorem 4.12: If f: (U, τ_R(X)) → (V, $\tau_R{}'$(Y)) is a slightly Nano-sg continuous surjection and U is Nano-sg connected, then V is connected.

Proof: Suppose V is not connected, then there exists non empty disjoint Nano open sets M and N such that V = M ∪ N. Therefore, M and N are Nano clopen sets in V. Since, f is slightly Nano-sg continuous, f^{-1}(M) and f^{-1}(N) are non empty disjoint Nano-sg open in U and U = f^{-1}(M) ∪ f^{-1}(N). This shows that U is not Nano-sg connected. This is a contradiction and hence, V is connected.

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Theorem 4.13: If f: (U, $\tau_R(X)$) → (V,$\tau_R'(Y)$) is a slightly Nano-sg - continuous and (V,$\tau_R'(Y)$) is locally indiscrete space then f is Nano-sg-continuous.

Proof: Let N be an Nano-open subset of V. Since, (V, $\tau_R'(Y)$) is a locally indiscrete space, N is Nano-closed in V. Since, f is slightly Nano-sg continuous, f^{-1}(N) is Nano-sg -open in U . Hence, f is Nano-sg continuous.

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