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NEW VERSION OF SOFT NANO COMPACTNESS AND SOFT NANO CONNECTEDNESS

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ABSTRACT. Purpose of this paper is to give insight to the soft nano compactness which is the generalization of property of soft nano closedness. Precisely, soft nano gω-compactness is introduced and the conditions are established for perfectly soft nano gω-continuous onto functions, strongly soft nano gω-continuous onto functions and soft nano gω-irresolute functions to be soft nano gω-compactness. Furthermore, we briefly describe the characterizations of soft nano gω-connectedness. Also, proved the fact that soft nano gω-connectedness is under soft nano gω-irresolute surjections.

1. INTRODUCTION

In various areas of mathematics, the role of compactness, wherein each open covering has limited subcovering is very much significant. Simultaneously, pertaining to connectedness theorems, lemma, propositions and corollaries have been investigated by many researchers. Kuratowski [6] introduced connectedness between sets in general topology.

Main results for compactness and connectedness in General topology, Nano topology, Neutrosophic topology, Intuitionistic fuzzy topology, Ideal topology and Soft nano topology are studied rigorously and the benefits from this study

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invoked for their generalization. The stronger and weaker forms of compactness and connectedness were presented in the course of time. The concepts of as b-connectedness [1], s-connectedness [3], soft p-connectedness [8] were studied. S.S.Benchalli et al. [2] introduced gb-compactness and gb-connectedness in general topology. In 2018, topics like nano compactness and nano-connectedness was putforth by S. Krishnaprakash et.al. [5]. Related matter of nano AΨ-connectedness and nano AΨ-compactness given by R.Jeevitha et.al. [4] in 2019. Existance of miscellaneous characters paved the way for advent of sn gω-compactness and sn gω-connectedness.

Objective of this paper is to express some characterizations of soft nano compact spaces in terms of soft nano basic open covers, soft nano Lindelof spaces, soft nano continuous mappings and properties of soft nano gω-compact spaces in terms of soft nano gω-continuous maps, soft nano gω-strongly continuous maps, soft nano gω-perfectly continuous maps. Also, soft nano connectedness relation with respect to soft nano boundary, soft nano discrete space and soft nano gω-connectedness.

2. Preliminaries

Definition 2.1. *[5] In a nano topological space, the collection of nano open sets $\{Q_k : k \in K\}$ is called nano open cover of nano subset H of U_1 if $H \subset \{Q_k : k \in K\}$.*

Definition 2.2. *[5] In a nano topological space if each nano open covering has a finite subcovering, then it is nano compact.*

Definition 2.3. *[5] In a nano topological space if each nano open covering has a countable subcovering, then it is nano- lindelof.*

Definition 2.4. *[2] In a topological space X_1, if X_1 canâĂŹt be written as union of disjoint gb-open sets then it is gb-connected.*

Definition 2.5. *[2] Subsequent statements are equivalent:*

(1) *X_1 being gb-connected.*
(2) *$\emptyset$ and X_1 are only subsets of X_1 where they are gb-clopen.*
(3) *Every gb-continuous function of X_1 to discrete space X_2 with minimum two points is a invariable function.*

3. Soft Nano Compactness and their properties

Definition 3.1. *In a soft nano topological space* $(\tau_{R'}(X_1), U_1, O_1)$*, a collection* $(P^*, O_1)_m$ *for each* $m \in M$ *of soft nano open sets is known as soft nano open cover of soft nano subset* (V^*, O_1) *of* $(\tau_{R'}(X_1), U_1, O_1)$ *whenever* $(V^*, O_1) \subset \cup_{m\in M}\{(P^*, O_1)_m\}$.

Definition 3.2. *In a soft nano topological space* $(\tau_{R'}(X_1), U_1, O_1)$*, a collection* $(P^*, O_1)_m$ *for each* $m \in M$ *of soft nano* $g\omega$*-open sets is known as soft nano* $g\omega$*-open cover of soft nano subset* (V^*, O_1) *of* $(\tau_{R'}(X_1), U_1, O_1)$ *whenever* $(V^*, O_1) \subset \cup_{m\in M}\{(P^*, O_1)_m\}$.

Definition 3.3. *For a soft nano subset* (L^*, O_1) *is called soft nano compact if* (L^*, O_1) *is soft nano compact as a subspace of* $(\tau_{R'}(X_1), U_1, O_1)$.

Definition 3.4. *Each soft nano* $g\omega$*-open of* $(\tau_{R'}(X_1), U_1, O_1)$ *having a finite soft nano* $g\omega$*-subcover is called soft nano* $g\omega$*-compact space of* $(\tau_{R'}(X_1), U_1, O_1)$.

Definition 3.5. *In a* $(\tau_{R'}(X_1), U_1, O_1)$*, a soft nano subset* (V^*, O_1) *is known to be soft nano* $g\omega$*-compact relative to* $(\tau_{R'}(X_1), U_1, O_1)$ *if each collection* $(P^*, O_1)_m$ *for all* $m \in M$ *of sn-O*(X_1, O_1) *subsets, such that* $(V^*, O_1) \subset \cup_{m\in M}\{(P^*, O_1)_m\}$.

Definition 3.6. *A soft nano subset* (V^*, O_1) *of* $(\tau_{R'}(X_1), U_1, O_1)$ *is said to be soft nano* $g\omega$*-compact if* (V^*, O_1) *is sn* $g\omega$*-compact as a subspace of* $(\tau_{R'}(X_1), U_1, O_1)$.

Theorem 3.1. *Every sn* $g\omega$*-compact space is sn-compact.*

Proof. Let $(\tau_{R'}(X_1), U_1, O_1)$ be a sn $g\omega$-compact and consider a sn open cover $(V^*, O_1)_m$ which is a collection of sn open set $(V^*, O_1)_m$ in $(\tau_{R'}(X_1), U_1, O_1)$. From [7], every sn open set is sn $g\omega$-open set. Now sn $g\omega$-open cover $(V^*, O_1)_m$ contains a finite sn subcover, as $(\tau_{R'}(X_1), U_1, O_1)$ is sn $g\omega$-compact. Therefore $(\tau_{R'}(X_1), U_1, O_1)$ is sn compact. □

Definition 3.7. *If each sn open cover of* $(\tau_{R'}(X_1), U_1, O_1)$ *has a sn countable sn subcover, then* $(\tau_{R'}(X_1), U_1, O_1)$ *is called a sn-Lindelof space.*

Theorem 3.2. *Each sn* $g\omega$*-compact space is sn-Lindelof space but not conversely.*

Proof. Let $(P^*, O_1)_m$ for each $m \in M$ be a sn open cover of $(\tau_{R'}(X_1), U_1, O_1)$, where $(\tau_{R'}(X_1), U_1, O_1))$ is sn-compact and it has finite subcover $\{(P^*, O_1)_m$: m=1, 2, 3,..., n}. We know that every countable subcover has finite subcover and thus $(P^*, O_1)_m$ for each $m \in M$ has a countable subcover {$(P^*, O_1)_m$; m=1, 2, 3,..., n}. Therefore $(\tau_{R'}(X_1), U_1, O_1)$ is sn-Lindelof space.Conversely, the set of all ordinal numbers ω_1 is countably sn-compact but not sn-compact, as it has no finite sn-subcover. □

Theorem 3.3. *Under a sn-continuous map image of sn-Lindelof is sn-compact.*

Proof. Let $(P^*, O_1)_m$ for each $m \in M$ be a sn open cover of $(\tau_{R''}(X_2), U_2, O_2)$ of sn-continuous map $F : (\tau_{R'}(X_1), U_1, O_1) \to (\tau_{R''}, (X_2), U_2, O_2)$ from a sn-Lindelof space $(\tau_{R'}(X_1), U_1, O_1)$ onto sn-topological space. Here $\{F^{-1}(P^*, O_1)_m : m \in M\}$ is sn-open cover of $(\tau_{R'}(X_1), U_1, O_1)$ and it has a continuous sub-cover $\{F^{-1}(P^*, O_1)_m : m = 1, 2, 3, ..., n\}$ as $(\tau_{R'}(X_1), U_1, O_1)$ is sn-Lindelof. Now $F(U_1) = U_2 = \cup_{m \in M}(P^*, O_1)_m$ as $X_1 = \cup_{m \in M} F^{-1}(P^*, O_1)_m$, where $\{(P^*, O_1)_1, (P^*, O_1)_2, (P^*, O_1)_3, ..., (P^*, O_1)_m\}$ is a countable subfamily of $\{(P^*, O_1)_m : m \in M\}$ for $(\tau_{R''}, (X_2), U_2, O_2)$. Therefore $(\tau_{R''}, (X_2), U_2, O_2)$ is sn-Lindelof. □

Theorem 3.4. *For an onto, sn gω-continuous function $F : (\tau_{R'}(X_1), U_1, O_1) \to (\tau_{R''}, (X_2), U_2, O_2)$, if $(\tau_{R'}(X_1), U_1, O_1)$ is sn gω-compact, then $(\tau_{R''}, (X_2), U_2, O_2)$ is sn gω-compact.*

Proof. F is sn gω-continuous function and here let $(L^*, O_1)_m$ for each $m \in M$ be sn open cover of $(\tau_{R''}, (X_2), U_2, O_2)$. Then $\{F^{-1}(L^*, O_1)_m : m \in M\}$ which is sn gω-open cover of $(\tau_{R'}(X_1), U_1, O_1)$ contains a sn finite subcover $\{F^{-1}(L^*, O_1)_m : m = 1, 2, 3, ..., n\}$. Hence $(\tau_{R'}(X_1), U_1, O_1) = \cup_{m=1}^{n}[F^{-1}(L^*, O_1)_m]$ implies

$$F(\tau_{R'}(X_1), U_1, O_1) = \cup_{m=1}^{n}(L^*, O_1)_m).$$

We have $(\tau_{R''}, (X_2), U_2, O_2) = \cup_{m=1}^{n}\{(L^*, O_1)_m) : m \in M\}$ as F is onto. Thus $\{(L^*, O_1)_1, (L^*, O_1)_2, (L^*, O_1)_3, ..., (L^*, O_1)_n\}$ is sn-finite subcover of $\{(L^*, O_1)_m) : m \in M\}$ for $(\tau_{R''}, (X_2), U_2, O_2)$. Hence $(\tau_{R''}, (X_2), U_2, O_2)$ is sn-compact. □

Theorem 3.5. *For a sn gω-strongly continuous surjective function $F : (\tau_{R'}(X_1), U_1, O_1) \to (\tau_{R''}, (X_2), U_2, O_2)$, if $(\tau_{R'}(X_1), U_1, O_1)$ is sn-compact, then $(\tau_{R''}, (X_2), U_2, O_2)$ is sn gω-compact.*

Proof. Consider $(L^*, O_1)_m$ for each $m \in M$ be a collection of sn gω-O(X_2, O_2). As F is sn gω-strongly continuous, $\{F^{-1}(L^*, O_1)_m : m \in M\}$ is sn open cover of $(\tau_{R'}(X_1), U_1, O_1)$. Now $(\tau_{R'}(X_1), U_1, O_1)$ has a finite subcover, $\{F^{-1}(L^*, O_1)_1, F^{-1}(L^*, O_1)_2, F^{-1}(L^*, ..., F^{-1}(L^*, O_1)_n\}$ as it is sn-compact. Also, $\{(L^*, O_1)_1, (L^*, O_1)_2,$

$(L^*, O_1)_3, ..., (L^*, O_1)_n\}$ is a finite sn gω-subcover as F is surjective and therefore $(\tau_{R''}, (X_2), U_2, O_2)$ is sn gω-compact. $\square$

Theorem 3.6. *For a sn gω-perfectly continuous, surjective function $F : (\tau_{R'}(X_1), U_1, O_1) \to (\tau_{R''}, (X_2), U_2, O_2)$, if $(\tau_{R'}(X_1), U_1, O_1)$ is sn-compact, then $(\tau_{R''}, (X_2), U_2, O_2)$ is sn gω-compact.*

Proof. We know that a sn gω-perfectly continuous

$$F : (\tau_{R'}(X_1), U_1, O_1) \to (\tau_{R''}, (X_2), U_2, O_2)$$

is sn gω-strongly continuous. Also, by Theorem 3.5 $(\tau_{R''}, (X_2), U_2, O_2)$ is sn gω-compact. $\square$

Theorem 3.7. *A $(\tau_{R'}(X_1), U_1, O_1)$ is sn-compact if and only if each sn basic open cover has a finite subcover.*

Proof. Each of the sn open cover of $(\tau_{R'}(X_1), U_1, O_1)$ has a finite subcover as it is sn-compact. In the converse part: if each sn basic open cover of $(\tau_{R'}(X_1), U_1, O_1)$ has a finite subcover and let $(D^*, O_1) = \{(H^*, O_1)_m : m \in M\}$ be sn open cover of $(\tau_{R'}(X_1), U_1, O_1)$. Suppose in $(\tau_{R'}(X_1), U_1, O_1)$, if $B_{sn} = \{(C^*, O_1)_i : i \in I\}$ is sn-open base then every $(H^*, O_1)_m$ is a finite sub cover of B_{sn}. Now $\{(C^*, O_1)_i : i = 1, 2, 3, ..., n\}$ is a finite sub collection and forms sub cover of (D^*, O_1). Therefore $(\tau_{R'}(X_1), U_1, O_1)$ is sn-compact. $\square$

4. Soft Nano Connectedness

Definition 4.1. *If a sn topological space $(\tau_{R'}(X_1), U_1, O_1)$ can't be written as disjoint union of two sn non-empty sn open sets, then it is sn-connected.*

Example 1. *Consider $U_1 = \{\epsilon_1, \epsilon_2, \epsilon_3, \epsilon_4\}$, $O_1 = \{K_1, K_2, K_3\}$, $X_1 = \{\epsilon_1, \epsilon_4\}$ and $U_1/R^1 = \{\{\epsilon_1\}, \{\epsilon_2\}, \{\epsilon_3\}, \{\epsilon_4\}\}$, $(\tau_{R'}(X_1) = \{U, , (K_1, \{\epsilon_1, \epsilon_4\}), (K_2, \{\epsilon_1, \epsilon_4\}), (K_3, \{\epsilon_1, \epsilon_4\})\}$ is sn-connected.*

Theorem 4.1. *A sn-continuous onto map $F : (\tau_{R'}(X_1), U_1, O_1) \to (\tau_{R''}, (X_2), U_2, O_2)$ where X_1 is sn-connected, then X_2 is sn-connected*

Proof. Let $X_2 = (P_1^*, O_1) \cup (P_2^*, O_1)$ is not sn-connected where (P_1^*, O_1) and (P_2^*, O_1) are disjoint sn-O(X_1, O_2). Here $X_2 = F^{-1}(P_1^*, O_1) \cup F^{-1}(P_2^*, O_1)$ and $F^{-1}(P_1^*, O_1)$ and $F^{-1}(P_2^*, O_1)$ be disjoint sn-O(X_1, O_1) as F is sn-continuous and surjective. But this is contradiction to the assumption that $(\tau_{R'}(X_1), U_1, O_1)$ is sn-connected. Therefore $(\tau_{R'}(X_1), U_1, O_1)$ is sn-connected. $\square$

Theorem 4.2. *$(\tau_{R'}(X_1), U_1, O_1)$ is sn-connected if and only if each sn non empty proper sn-subset of $(\tau_{R'}(X_1), U_1, O_1)$ contains a sn non-empty sn boundary.*

Proof. Assume $(\tau_{R'}(X_1), U_1, O_1)$ to be sn-disconnected and then $U_1 = (P_1^*, O_1) \cup (P_2^*, O_1)$ where (P_1^*, O_1) and (P_2^*, O_1) are both sn-clopen disjoint in U_1. Here $(P_1^*, O_1)^1 = (P_1^*, O_1)^\circ = \overline{(P_1^*, O_1)}$ but $Bd(P_1^*, O_1) = \overline{(P_1^*, O_1)} - (P_1^*, O_1)^\circ$. Therefore $Bd(P_1^*, O_1) =$ is contradiction to our assumption. Thus $(\tau_{R'}(X_1), U_1, O_1)$ must be sn-connected. In the converse part: consider $(\tau_{R'}(X_1), U_1, O_1)$ be sn-connected and $Bd(L^*, O_1) =$ where (L^*, O_1) is sn-proper subset of $(\tau_{R'}(X_1), U_1, O_1)$. Again $\overline{(L^*, O_1)} = (L^*, O_1)^\circ \cup Bd(L^*, O_1) = (L^*, O_1) \cup Bd\overline{(L^*, O_1)}$. Thus (L^*, O_1) is both sn-clopen in $(\tau_{R'}(X_1), U_1, O_1)$ as $(L^*, O_1) = (L^*, O_1)^\circ = \overline{(L^*, O_1)}$. Hence $(\tau_{R'}(X_1), U_1, O_1)$ is sn-disconnected. This contradicts the assumption. Therefore each sn-proper sn-subset of $(\tau_{R'}(X_1), U_1, O_1)$ has sn-non empty boundary. $\square$

Definition 4.2. *A $(\tau_{R'}(X_1), U_1, O_1)$ is sn $g\omega$-connected, if $(\tau_{R'}(X_1), U_1, O_1)$ cannot be articulated as disjoint union of two sn non empty sn $g\omega$ open sets. In $(\tau_{R'}(X_1), U_1, O_1)$ sn subset is sn-$g\omega$-connected, if it is sn-$g\omega$-connected as a subspace of $(\tau_{R'}(X_1), U_1, O_1)$.*

Theorem 4.3. *A $(\tau_{R'}(X_1), U_1, O_1)$ is sn $g\omega$-connected, then it is sn-disconnected but converse is not true.*

Proof. Consider a sn gω-connected $(\tau_{R'}(X_1), U_1, O_1)$ space. Let $(\tau_{R'}(X_1), U_1, O_1)$ be disconnected, here $(\tau_{R'}(X_1), U_1, O_1) = (P_1^*, O_1) \cup (P_2^*, O_1)$ where (P_1^*, O_1) and (P_2^*, O_1) are non-empty disjoint sn-O(X_1, O_1). But (P_1^*, O_1) and (P_2^*, O_1) are sn gω-open and $(\tau_{R'}(X_1), U_1, O_1) = (P_1^*, O_1) \cup (P_2^*, O_1)$ where (P_1^*, O_1) and (P_2^*, O_1) are non-empty disjoint sn gω-O(X_1, O_1). Therefore by the contradiction $(\tau_{R'}(X_1), U_1, O_1)$ is sn gω-connected. $\square$

Converse is not true by the following example.

Example 2. *Consider $U_1 = \{\epsilon_1, \epsilon_2, \epsilon_3, \epsilon_4\}$, $O_1 = \{K_1, K_2, K_3\}$ and $(\tau_{R'}(X_1), U_1, O_1)$ $= \{U, \emptyset, (K_1, \{\epsilon_1\}), (K_2, \{\epsilon_1\}), (K_3, \{\epsilon_1\}), (K_1, \{\epsilon_1, \epsilon_2, \epsilon_4\}), (K_2, \{\epsilon_1, \epsilon_2, \epsilon_4\}), (K_3, \{\epsilon_1, \epsilon_2, \epsilon_4\}), (K_1, \{\epsilon_2, \epsilon_4\}), (K_2, \{\epsilon_2, \epsilon_4\}), (K_3, \{\epsilon_2, \epsilon_4\})\}$. Here $(\tau_{R'}(X_1), U_1, O_1)$ is sn-connected. Now $\{(K_1, \{\epsilon_2, \epsilon_3, \epsilon_4\}), (K_2, \{\epsilon_2, \epsilon_3, \epsilon_4\}), (K_3, \{\epsilon_2, \epsilon_3, \epsilon_4\})\}$ is sn $g\omega$-clopen* *but here U and $\emptyset$ are only sn-clopen subsets of $(\tau_{R'}(X_1), U_1, O_1)$. So $(\tau_{R'}(X_1), U_1, O_1)$ is not sn gω-connected.*

Theorem 4.4. *Subsequents are equivalent, for a $(\tau_{R'}(X_1), U_1, O_1)$:*

(1) *$(\tau_{R'}(X_1), U_1, O_1)$ is sn gω-connected.*
(2) *U and $\emptyset$ are only sn-clopen subsets of $(\tau_{R'}(X_1), U_1, O_1)$.*
(3) *For a sn gω-continuous map of $(\tau_{R'}(X_1), U_1, O_1)$ into sn-discrete space $(\tau_{R''}(X_2), U_2, O_2)$ is a invariable map with minimum two points.*

Proof.

(1) $\Rightarrow$ (2), Consider $(\tau_{R'}(X_1), U_1, O_1)$ a sn gω-connected space. Let (L^*, O_1) and $(L^*, O_1)^c$ are both sn gω-clopen. Now $(L^*, O_1) = \emptyset$ or $(L^*, O_1) = U_1$ as $(\tau_{R'}(X_1), U_1, O_1)$ is sn gω-connected.
(2) $\Rightarrow$ (1), $(\tau_{R'}(X_1), U_1, O_1) = (L_1^*, O_1) \cup (L_2^*, O_1)$ where (L_1^*, O_1) and (L_2^*, O_1) are disjoint sn gω-subsets. Here (L_1^*, O_1) sn gω-clopen. But by assumption $(L_1^*, O_1) = U_1$ or $\emptyset$. Therefore $(\tau_{R'}(X_1), U_1, O_1)$ is sn gω-connected.

(2) $\Rightarrow$ (3), In a sn gω-continuous map $F : (\tau_{R'}(X_1), U_1, O_1) \to (\tau_{R''}(X_2), U_2, O_2)$ has sn gω-clopen covering $\{F^{-1}(S^*, O_1) : (S^*, O_1) \in (\tau_{R''}(X_2), U_2, O_2)$.For every $(S^*, O_1) \in (\tau_{R''}(X_2), U_2, O_2)$ $F^{-1}(S^*, O_1) = U_1$ or $\emptyset$ by assumption. Here F disagrees to be a function. Now F is a invariable function which is shown by the existance of minimum point $(S^*, O_1) \in (\tau_{R''}(X_2), U_2, O_2)$ such that $F^{-1}(S^*, O_1) \neq \emptyset$. Thus $F^{-1}(S^*, O_1) = U_1$.

(3) $\Rightarrow$ (2), Consider a map $F : (\tau_{R'}(X_1), U_1, O_1) \to (\tau_{R''}(X_2), U_2, O_2)$ defined as $F(S^*, O_1) = \{(S^*, O_1)\}$ and $F[(S^*, O_1^c)] = (S_2^*, O_1)$ where (S^*, O_1) is sn gω-clopen in $(\tau_{R'}(X_1), U_1, O_1)$ and here we assumed that $(S^*, O_1) \neq \emptyset$ and hence F is a sn gω-continuous. Therefore by hypothesis, F is a invariable map and $(S^*, O_1) = (S_{2n}^*, O_1)$. Hence $(S^*, O_1) = U_1$. $\square$

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