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Gη-Homeomorphism in Topological Ordered Spaces

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Abstract:

The aim of this paper is to introduce a new class of closed map, open map and homeomorphism in topological ordered spaces called xgη-closed map, xgη-open map are obtained. The concept of homeomorphism is called xgη-homeomorphism is defined and obtained some of its properties.

Keywords

xgη-closed map, xgη-open map, xgη-homeomorphism.

1. INTRODUCTION

In 1965, Nachbin [13] initiated the study of topological ordered spaces. A new class of gη-closed maps, gη-open maps and gη-homeomorphism has been introduced by Subbulakshmi et al [17]. In 2001, Veera kumar [20] introduced the study of i-closed, d-closed and b-closed sets. In 2017, Amarendra babu [1] introduced g*-closed sets in topological ordered spaces. In 2019, Dhanapakyam [7] introduced βg*-closed sets in topological ordered spaces. In 2002, Veera kumar [20] introduced Homeomorphism in topological ordered spaces. In 2020, Subbulakshmi et al [18] introduced gη-closed, continuity, and contra continuity in topological ordered spaces. In this paper a new class of xgη-homeomorphism in topological ordered spaces are defined and some of their properties are analyzed. Throughout this paper [x = i, d, b]

2. PRELIMINARIES

Definition : 2.1

A subset A of a topological space (X, τ) is called

(i) α-open set [2] if $A \subseteq int(cl(int(A)))$, α-closed set if $cl(int(cl(A))) \subseteq A$.

(ii) semi-open set [10] if $A \subseteq cl(int(A))$, semi-closed set if $int(cl(A) \subseteq A$.

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(iii) η-open set [14] if A ⊆ int (cl(int(A))) ∪ cl (int (A)), η-closed set if cl (int (cl (A))) ∩ int(cl(A)) ⊆ A.

Definition : 2.2 A subset A of a topological space (X, τ) is called

(i) g-closed set [11] if cl(A) ⊆ U whenever A ⊆ U and U is open in (X, τ).

(ii) g*-closed set [19] if cl(A) ⊆ U whenever A ⊆ U and U is g-open in (X, τ).

(iii) gη-closed set [15] if ηcl(A) ⊆ U whenever A ⊆ U and U is open in (X, τ).

Definition : 2.3 A function f: (X, τ) → (Y, σ) is called

(i) continuous [3] if f^{-1}(V) is a closed in (X, τ) for every closed set V of (Y, σ).

(ii) semi-continuous [10] if f^{-1}(V) is a semi-closed in (X, τ) for every closed set V of (Y, σ).

(iii) α-continuous [5] if f^{-1}(V) is a α-closed in (X, τ) for every closed set V of (Y, σ).

(iii) η-continuous [16] if f^{-1}(V) is a η-closed in (X, τ) for every closed set V of (Y, σ).

(iv) gη-continuous [16] if f^{-1}(V) is a gη-closed in (X, τ) for every closed set V of (Y, σ).

Definition: 2.4

A bijective function f: (X, τ) → (Y, σ) is called

(i) homeomorphism [12] if f is both continuous map and open map.

(ii) semi-homeomorphism [4,6] if f is both semi-continuous map and semi-open map.

(iii) α-homeomorphism [5] if f is both α-continuous map and α-open map.

(iv) η-homeomorphism [17] if f is both η-continuous map and η-open map.

(v) gη-homeomorphism [17] if f is both gη-continuous map and gη-open map.

Definition 2.5: [20] A topological ordered space is a triple (X, τ, ≤), where τ is a topology on X and ≤ is a partial order on X.

Let A be a subset of topological ordered space (X, τ, ≤).

For any x ∈ X,

(i) $[x, \rightarrow] = \{ y \in X/x \leq y\}$ and

(ii) $[\leftarrow, x]$ = $\{y \in X/y \leq x\}$.

The subset A is said to be

(i) increasing if A = i(A), where i(A) = $\bigcup_{a \in A}[a, \rightarrow]$ and

(ii) decreasing if A = d (A), where d(A) = $\bigcup_{a \in A}[\leftarrow, a]$

(iii) balanced if it is both increasing and decreasing.

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The complement of an increasing set is a decreasing set and the complement of a decreasing set is an increasing set.

Definition: 2.6 [20] A subset A of a topological ordered space (X, τ, ≤) is called

(i) x-closed set [18] if it is both increasing (resp. decreasing, increasing and decreasing) set and closed set.

(ii) xα-closed set [18] if it is both increasing (resp. decreasing, increasing and decreasing) set and α-closed set.

(iii) xsemi-closed set [18] if it is both increasing (resp. decreasing, increasing and decreasing) set and semi-closed set.

Definition: 2.7 A function f : (X, τ, ≤) → (Y, σ, ≤) is said to be

(i) xclosed map [20] if the image of every closed set in (X, τ, ≤) is an x-closed set in (Y, σ, ≤).

(ii) xα-closed map [20] if the image of every closed set in (X, τ, ≤) is an xα-closed set in (Y, σ, ≤).

(iii) xsemi-closed map [20] if the image of every closed set in (X, τ, ≤) is an xsemi-closed set in (Y, σ, ≤).

Definition: 2.8 A function f : (X, τ, ≤) → (Y, σ, ≤) is said to be

(i) xopen map [8] if the image of every open set in (X, τ, ≤) is an x-open set in (Y, σ, ≤).

(ii) xα-open map [8] if the image of every open set in (X, τ, ≤) is an xα-open set in (Y, σ, ≤).

(iii) xsemi-open map [8] if the image of every closed set in (X, τ, ≤) is an xsemi-open set in (Y, σ, ≤).

Definition: 2.9 A function f : (X, τ, ≤) → (Y, σ, ≤) is said to be

(i) x-homeomorphism [9] if f is both x-continuous function and x-open map.

(ii) xα-homeomorphism [9] if f is both xα-continuous function and x-open map.

(iii) xsemi-homeomorphism [9] if f is both xsemi-continuous function and x-open map.

3. igη-closed map

Definition : 3.1 A function f : (X, τ, ≤) → (Y, σ, ≤) is said to be an iη-closed map if the image of every closed set in (X, τ, ≤) is an iη-closed set in (Y, σ, ≤).

Definition : 3.2 A function f : (X, τ, ≤) → (Y, σ, ≤) is said to be an igη-closed map if the image of every closed set in (X, τ, ≤) is an igη-closed set in (Y, σ, ≤).

Theorem 3.3: Every i-closed, isemi-closed, iα-closed, iη-closed maps are igη-closed map, but not conversely.

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Proof: The proof follows from the fact that every closed, semi-closed, α-closed, η-closed maps are gη-closed maps. [17]. Then every i-closed, isemi-closed, iα-closed, iη-closed maps are igη-closed map.

Example 3.4: Let X = Y = {a, b, c}, τ ={X, φ, {a}, {b}, {a, b}} and σ ={Y, φ, {a}}. ≤ = {(a, a), (b, b), (c, c), (a, b), (c, b)}. Define a map f: (X, τ, ≤) → (Y, σ, ≤) by f (a) = a, f (b) = c, f (c) = b. This map is igη-closed map, but not i-closed, isemi-closed, iα-closed, igα-closed, ig*-closed, isg-closed, iη-closed map. Since for the closed set V= {a, c} in (X, τ, ≤). Then f (V) = {a, b} is igη-closed but not i-closed, isemi-closed, iα-closed, igα-closed, ig*-closed, isg-closed, iη-closed in (Y, σ, ≤).

4. dgη-closed map

Definition : 4.1 A function f : (X, τ, ≤) → (Y, σ, ≤) is said to be a dη-closed map if the image of every closed set in (X, τ, ≤) is a dη-closed set in (Y, σ, ≤).

Definition : 4.2 A function f : (X, τ, ≤) → (Y, σ, ≤) is said to be a dgη-closed map if the image of every closed set in (X, τ, ≤) is a dgη-closed set in (Y, σ, ≤).

Theorem 4.3: Every d-closed, dsemi-closed, dα-closed, dη-closed maps are dgη-closed map, but not conversely.

Proof: The proof follows from the fact that every closed, semi-closed, α-closed, η-closed maps are gη-closed map [17]. Then every d-closed, dsemi-closed, dα-closed, dη-closed maps are dgη-closed map.

Example 4.4 : Let X = Y = {a, b, c}, τ ={X, φ, {a}} and σ ={Y, φ, {a}, {b, c}} . ≤ = {(a, a), (b, b), (c, c), (a, b), (b, c), (a, c)}. Define a map f: (X, τ, ≤) → (Y, σ, ≤) by f (a) = c, f (b) = b, f(c) = a. This map is dgη-closed map but not d-closed, dsemi-closed, dα-closed, dη-closed map. Since for the closed set V= {b, c} in (X, τ, ≤). Then f (V) ={a, b} is dgη-closed but not d-closed, dsemi-closed, dα-closed, dη-closed in (Y, σ, ≤).

5. bgη-closed map

Definition : 5.1 A function f : (X, τ, ≤) → (Y, σ, ≤) is said to be a bη-closed map if the image of every closed set in (X, τ, ≤) is a bη-closed set in (Y, σ, ≤).

Definition : 5.2 A function f : (X, τ, ≤) → (Y, σ, ≤) is said to be a bgη-closed map if the image of every closed set in (X, τ, ≤) is a bgη-closed set in (Y, σ, ≤).

Theorem 5.3: Every b-closed, bα-closed maps are bgη-closed map, but not conversely.

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Proof: The proof follows from the fact that every closed, α-closed maps are gη-closed map [17]. Then every b-closed, bα-closed maps are bgη-closed map.

Example 5.4: Let X = Y = {a, b, c}, τ ={X, φ, {a}, {b, c}} and σ ={Y, φ, {a}, {b}, {a, b}} . ≤ = {(a, a), (b, b), (c, c), (a, c)}. Define a map f: (X, τ, ≤) → (Y, σ, ≤) by f (a) = b, f (b) = a, f (c) = c. This map is b gη-closed map but not b-closed, bα-closed map. Since for the closed set V= {a} in (X, τ, ≤). Then f (V) ={b} is bgη-closed but not b-closed, bα-closed in (Y, σ, ≤).

Theorem 5.5: Every bsemi-closed, bη-closed maps are bgη-closed map, but not conversely.

Proof: The proof follows from the fact that every semi-closed, η-closed maps are bgη-closed map [17]. Then every bsemi-closed, bη-closed maps are bgη-closed map.

Example 5.6: Let X = Y = {a, b, c}, τ ={X, φ, {a}, {b, c}} and σ ={Y, φ, {a}} . ≤ = {(a, a), (b, b), (c, c), (a, c)}. Define a map f: (X, τ, ≤) → (Y, σ, ≤) by f (a) = b, f (b) = a, f (c) = c. This map is bgη-closed map but not bsemi-closed, bη-closed map. Since for the closed set V= {b, c} in (X, τ, ≤). Then f (V) = {a, c} is bgη-closed but not bsemi-closed, bη-closed in (Y, σ, ≤).

6. igη open map

Definition :6.1 A function f : (X, τ, ≤) → (Y, σ, ≤) is said to be an iη-open map if the image of every open set in (X, τ, ≤) is an iη-open set in (Y, σ, ≤).

Definition :6.2 A function f : (X, τ, ≤) → (Y, σ, ≤) is said to be an igη-open map if the image of every open set in (X, τ, ≤) is an igη-open set in (Y, σ, ≤).

Theorem 6.3: Every i-open, isemi-open, iα-open, iη-open maps are igη-open map, but not conversely.

Proof: The proof follows from the fact that every open, semi-open, α-open, η-open maps are gη-open map [17]. Then every i-open, isemi-open, iα-open, iη-open maps are igη-open map.

Example 6.4: Let X = Y = {a, b, c}, τ ={X, φ, {b, c}} and σ ={Y, φ, {a}, {b, c}} . ≤ = {(a, a), (b, b), (c, c), (a, b), (b, c), (a, c)}. Define a map f: (X, τ, ≤) → (Y, σ, ≤) by f (a) = c, f (b) = b, f (c) = a. This map is igη-open map, but not i-open, isemi-open, iα-open, iη-open map. Since for the open set V= {b, c} in (X, τ, ≤). Then f (V) ={a, b} is igη-open but not i-open, isemi-open, iα-open, iη-open in (Y, σ, ≤).

7. dgη open map

Definition :7.1 A function f : (X, τ, ≤) → (Y, σ, ≤) is said to be a dη-open map if the image of every open set in (X, τ, ≤) is a dη-open set in (Y, σ, ≤).

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Definition :7.2 A function f : (X, τ, ≤) → (Y, σ, ≤) is said to be a dgη-open map if the image of every open set in (X, τ, ≤) is a dgη-open set in (Y, σ, ≤).

Theorem 7.3: Every d-open, dα-open maps are dgη-open map, but not conversely.

Proof: The proof follows from the fact that every open, α-open maps are gη-open map [17]. Then every d-open, dα-open maps are dgη-open map.

Example 7.4: Let X = Y = {a, b, c}, τ ={X, φ, {a, b}} and σ ={Y, φ, {a}, {b}, {a, b}} . ≤ = {(a, a), (b, b), (c, c), (a, b), (c, b)}. Define a map f: (X, τ, ≤) → (Y, σ, ≤) by f (a) = c, f (b) = b, f (c) = a. This map is dgη-open map, but not d-open, dα-open, map. Since for the open set V= {a, b} in (X, τ, ≤). Then f (V) = {b, c} is dgη-open but not d-open, dα-open in (Y, σ, ≤).

Theorem 7.5: Every dsemi-open, dη-open maps are dgη-open map, but not conversely.

Proof: The proof follows from the fact that every semi-open, η-open maps are dgη-open map [17]. Then every dsemi-open, dη-open maps are dgη-open map.

Example 7.6: Let X = Y = {a, b, c}, τ ={X, φ, {c}} and σ ={Y, φ, {a}} . ≤ = {(a, a), (b, b), (c, c), (a, b), (c, b)}. Define a map f: (X, τ, ≤) → (Y, σ, ≤) by f (a) = c, f (b) = a, f (c) = b. This map is dgη-open map, but not dsemi-open, dη-open map. Since for the open set V= {c} in (X, τ, ≤). Then f (V) ={b} is dgη-open but not dsemi-open, dη-open in (Y, σ, ≤).

8. bgη open map

Definition :8.1 A function f : (X, τ, ≤) → (Y, σ, ≤) is said to be a bη-open map if the image of every open set in (X, τ, ≤) is a bη-open set in (Y, σ, ≤).

Definition :8.2 A function f : (X, τ, ≤) → (Y, σ, ≤) is said to be a bgη-open map if the image of every open set in (X, τ, ≤) is a bgη-open set in (Y, σ, ≤).

Theorem 8.3: Every b-open, bα-open maps are bgη-open map, but not conversely.

Proof: The proof follows from the fact that every open, α-open maps are bgη-open map [17]. Then every b-open, bα-open maps are bgη-open map.

Example 8.4: Let X = Y = {a, b, c}, τ ={X, φ, {a}, {b, c}} and σ ={Y, φ, {a}, {b}, {a, b}} . ≤ = {(a, a), (b, b), (c, c), (a, c)}. Define a map f: (X, τ, ≤) → (Y, σ, ≤) by f (a) = b, f (b) = a, f (c) = c. This map is bgη-open map, but not b-open, bα-open map. Since for the open set V= {b, c} in (X, τ, ≤). Then f (V) = {a, c} is bgη-open but not b-open, bα-open in (Y, σ, ≤).

Theorem 8.5: Every bsemi-open, bη-open maps are bgη-open map, but not conversely.

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Proof: The proof follows from the fact that every semi-open, η-open maps are gη-open map [17]. Then every bsemi-open, bη-open maps are bgη-open map.

Example 8.6: Let X = Y = {a, b, c}, τ ={X, φ, {a}, {b, c}} and σ ={Y, φ, {a}} . ≤ = {(a, a), (b, b), (c, c), (a, c)}. Define a map f: (X, τ, ≤) → (Y, σ, ≤) by f (a) = b, f (b) = a, f (c) = c. This map is bgη-open map, but not bsemi-open, bη-open map. Since for the open set V= {a} in (X, τ, ≤). Then f (V) = {b} is bgη-open but not bsemi-open, bη-open in (Y, σ, ≤).

9. igη-Homeomorphism:

Definition: 9.1 A bijection function f : (X, τ, ≤) → (Y, σ, ≤) is called a iη-homeomorphism if f is both i η-continuous function and i η-open map.

Definition: 9.2 A bijection function f : (X, τ, ≤) → (Y, σ, ≤) is called a igη-homeomorphism if f is both i gη-continuous function and i gη-open map.

Theorem 9.3: Every i-homeomorphism, iα-homeomorphism are igη-homeomorphism but not conversely.

Proof: The proof follows from the fact that every i-continuous, iα-continuous functions are igη-continuous [18]. Also every i-open, iα-open maps are igη-open map. By theorem [6.3].

Example 9.4: Let X = Y = {a, b, c}, τ ={X, φ, {a}, {b}, {a, b}} and σ ={Y, φ, {a}, {b, c}} . ≤ = {(a, a), (b, b), (c, c), (a, c)}. Define a map f: (X, τ, ≤) → (Y, σ, ≤) by f (a) = b, f (b) = a, f (c) = c. This map is igη-homeomorphism, but not i-homeomorphism, iα-homeomorphism. Since for the closed set V= {a} in (Y, σ, ≤). Then f^{-1}(V) = {b} is igη-closed but not i-closed, iα-closed in (X, τ, ≤).

Theorem 9.5: Every isemi-homeomorphism, iη-homeomorphism are igη-homeomorphism but not conversely.

Proof: The proof follows from the fact that every isemi-continuous and iη-continuous functions are igη-continuous [18]. Also every isemi-open, iη-open maps are igη-open map. By theorem [6.3].

Example 9.6: Let X = Y = {a, b, c}, τ ={X, φ, {a}} and σ ={Y, φ, {a}, {b, c}} . ≤ = {(a, a), (b, b), (c, c), (a, c)}. Define a map f: (X, τ, ≤) → (Y, σ, ≤) by f (a) = b, f (b) = a, f (c) = c. This map is igη-homeomorphism, but not isemi-homeomorphism, iη-homeomorphism. Since for the closed set V= {b, c} in (Y, σ, ≤). Then f^{-1}(b, c) = {a, c} is igη-closed but not isemi-closed, iη-closed in (X, τ, ≤).

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10. dgη-Homeomorphism:

Definition 10.1 A bijection function f : (X, τ, ≤) → (Y, σ, ≤) is called a dη-homeomorphism if f is both dη-continuous function and dη-open map.

Definition 10.2 A bijection function f : (X, τ, ≤) → (Y, σ, ≤) is called a dgη-homeomorphism if f is both dgη-continuous function and dgη-open map.

Theorem 10.3: Every d-homeomorphism, dα-homeomorphism are dgη- homeomorphism but not conversely.

Proof: The proof follows from the fact that every d-continuous, dα-continuous functions are dgη-continuous [18]. Also every d-open, dα-open maps are dgη-open map. By theorem [7.3].

Example 10.4: Let X = Y = {a, b, c}, τ ={X, φ, {a}, {b}, {a, b}} and σ ={Y, φ, {a}, {b, c}} . ≤ = {(a, a), (b, b), (c, c), (a, c)}. Define a map f: (X, τ, ≤) → (Y, σ, ≤) by f (a) = b, f (b) = a, f (c) = c. This map is dgη-homeomorphism, but not d-homeomorphism, dα-homeomorphism. Since for the closed set V= {a} in (Y, σ, ≤). Then $f^{-1}(V)$ = {b} is dgη-closed but not d-closed, dα-closed in (X, τ, ≤).

Theorem 10.5: Every dsemi-homeomorphism, dη-homeomorphism are dgη-homeomorphism but not conversely.

Proof: The proof follows from the fact that every dsemi-continuous, dη-continuous functions are dgη-continuous [18]. Also every dsemi-open, dη-open maps are dgη-open map. By theorem [7.5].

Example 10.6: Let X = Y = {a, b, c}, τ ={X, φ, {a}} and σ ={Y, φ, {a}, {b, c}} . ≤ = {(a, a), (b, b), (c, c), (a, c)}. Define a map f: (X, τ, ≤) → (Y, σ, ≤) by f (a) = b, f (b) = a, f (c) = c. This map is dgη-homeomorphism, but not dsemi-homeomorphism, dη-homeomorphism. Since for the closed set V= {b, c} in (Y, σ, ≤). Then $f^{-1}(V)$ = {a, c} is dgη-closed but not dsemi-closed, dη-closed in (X, τ, ≤).

11. bgη-Homeomorphism:

Definition 11.1 A bijection function f : (X, τ, ≤) → (Y, σ, ≤) is called a bη-homeomorphism if f is both bη-continuous function and bη-open map.

Definition 11.2 A bijection function f : (X, τ, ≤) → (Y, σ, ≤) is called a bgη-homeomorphism if f is both bgη-continuous function and bgη-open map.

Theorem 11.3: Every bsemi-homeomorphism, bα-homeomorphism, bη-homeomorphism, are bgη-homeomorphism but not conversely.

Proof: The proof follows from the fact that every bsemi-continuous, bα-continuous, bη-continuous functions are bgη-continuous [18]. Also every bsemi-open, bα-open, bη-open, maps are bgη-open map. By theorem [8.3 and 8.5].

Example 11.4: Let X = Y = {a, b, c}, τ ={X, φ, {a}} and σ ={Y, φ, {a}, {b, c}} . ≤ = {(a, a), (b, b), (c, c), (a, c)}. Define a map f: (X, τ, ≤) → (Y, σ, ≤) by f (a) = b, f (b) = a, f (c) = c. This map is bgη-homeomorphism, but not bsemi-homeomorphism, bα-homeomorphism, bη-homeomorphism. Since for the closed set V= {b, c} in (Y, σ, ≤). Then f^{-1}(V) = {a, c} is bgη-closed but not bsemi-closed, bα-closed, bη-closed in (X, τ, ≤).

Theorem 11.5 : Every b-homeomorphism is bgη-homeomorphism but not conversely.

Proof: The proof follows from the fact that every b-continuous functions is bgη-continuous [18]. Also every b-open map is bgη-open map. By theorem [8.3].

Example 11.6: Let X = Y = {a, b, c}, τ ={X, φ, {a}, {b}, {a, b}} and σ ={Y, φ, {a}, {b, c}} . ≤ = {(a, a), (b, b), (c, c), (a, c)}. Define a map f: (X, τ, ≤) → (Y, σ, ≤) by f (a) = b, f (b) = a, f (c) = c. This map is bgη-homeomorphism, but not b-homeomorphism. Since for the closed set V= {a} in (Y, σ, ≤). Then f^{-1}(V) = {b} is bgη-closed but not b-closed in (X, τ, ≤).

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