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Some Stronger Forms of g^*Pre Continuous Functions in Topology

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Abstract

In this paper, we introduce and study some stronger forms of g^*p-continuous functions namely, strongly g^*p-continuous, perfectly g^*p-continuous and completely g^*p-continuous functions in topological spaces. Further we introduce the concepts of strongly g^*p-closed and strongly g^*p-open maps and obtain some of their properties.

Keywords: *g^*p-closed sets, strongly g^*p-continuous functions, perfectly g^*p-continuous functions, completely g^*p-continuous functions, strongly g^*p-closed maps and strongly g^*p-open maps.*

1 Introduction

In 1982, Mashhour et. al. [12] introduced preopen sets and pre-continuity in topology. Levine [8] introduced the class of generalized closed (g-closed) sets in topological spaces. The generalized continuity was studied in recent years by Balachandran et.al. Devi et.al, Maki et.al, [3, 5, 9]. Levine [6], Noiri [16] and Arya and Gupta [2] introduced and investigated the concept of strongly continuous , perfectly continuous and completely continuous functions respectively which are stronger than continuous functions. Later, Sundaram [18] defined and studied strongly g-continuous functions and perfectly g-continuous functions in topological spaces. Generalized closed (g-closed) maps were introduced by Malghan[11]. In 2013, P.G.Patil et al.[17] studied the concept of stronger forms of $\omega\alpha$ - continuous functions in topological spaces. Veerakumar [19] introduced and studied the concept of g^*p-closed sets, g^*p-continuity, g^*p-irresolute functions, g^*p-closed maps, g^*p-open maps and T_p^*-spaces for general topology.

In this paper, we introduce and study some stronger forms of g^*p-continuous functions namely, strongly g^*p-continuous, perfectly g^*p-continuous and completely g^*p-continuous functions in topological spaces. Further, we introduce the concepts of stronlgly g^*p-closed and strongly g^*p-open maps and obtain some of their properties.

2 Preliminaries

Throughout this paper (X, τ), (Y, σ) and (Z, η) represent non-empty topological spaces on which no separation axioms are assumed unless explicitly stated and they are simply written X, Y and Z respectively. For a subset A of a topological space (X, τ), the closure of A, the interior of A with respect to τ are denoted by $cl(A)$ and $int(A)$ respectively. The complement of A is denoted by A^c. The α-closure (resp. pre-closure) of A is the smallest α-closed (resp. preclosed) set containing A and is denoted by $\alpha cl(A)$ (resp. $pcl(A)$).

Before entering into our work we recall the following definitions from various authors.

Definition 2.1 *A subset A of a topological space (X, τ) is called a*

1. *pre-open set [12] if $A \subseteq int(cl(A))$ and pre-closed set if $cl(int(A)) \subseteq A$.*
2. *α-open set [15] if $A \subseteq int(cl(int(A)))$ and α-closed set if $cl(int(cl(A))) \subseteq A$.*

Definition 2.2 *A subset A of a topological space (X, τ) is called g-closed [8] (resp. g^*p-closed[19]) set if $cl(A) \subseteq G$ (resp. $pcl(A) \subseteq G$) whenever $A \subseteq G$ and G is open (resp.g -open) in (X, τ).*

Definition 2.3 *A of a topological space (X, τ) is called a T_p^*-space [19] if every g^*p-closed set is closed.*

Definition 2.4 *A map $f : X \to Y$ is called pre-continuous [12] (resp. g-continuous [3] and g^*p-continuous [19]) if $f^{-1}(V)$ is pre-closed (resp. g-closed and g^*p-closed)in X for every closed set V in Y.*

Definition 2.5 *A map $f : X \to Y$ is called a irresolute [4] (resp. gc-irresolute [5] and g^*p-irresolute [19]) if $f^{-1}(V)$ is semi-closed (resp. g-closed and g^*p-closed) in X for every semi-closed (resp. g-closed and g^*p-closed) set V of Y.*

Definition 2.6 *A map $f : X \to Y$ is called a*

1. *strongly continuous [6] if $f^{-1}(V)$ is both open and closed in X for each subset V in Y.*

2. *perfectly continuous [16] if $f^{-1}(V)$ is both open and closed in X for each open set V in Y.*

3. *completely continuous [2] if $f^{-1}(V)$ is regular-open in X for each open set V in Y.*

4. *strongly g-continuous [18] if $f^{-1}(V)$ is g-open in X for each open set V in Y.*

5. *perfectly g-continuous [18] if $f^{-1}(V)$ is both open and closed in X for each g-open set V in Y.*

Definition 2.7 *A map $f : X \to Y$ is called a*

1. *M-preopen (resp. M-preclosed) [14] if $f(V)$ is preopen (resp. preclosed) set in Y for every preopen (resp. preclosed) set V of X.*

2. *g^*p-open (resp. g^*p-closed) [19] if $f(V)$ is g^*p-open (resp. g^*p-closed) in Y for each open (resp. closed) set V in Y.*

3 Stronger Forms of Continuous Functions

In this section, we introduce strongly g^*p-continuous functions, perfectly g^*p-continuous functions and completely g^*p-continuous functions and study some of their properties.

Definition 3.1 *A function $f : X \to Y$ is said to be strongly g^*-precontinuous (briefly strongly g^*p-continuous) if the inverse image of every g^*p-closed set in Y is closed in X.*

Theorem 3.2 *A function $f : X \to Y$ is strongly g^*p-continuous if and only if the inverse image of every g^*p-open set in Y is open in X.*

Theorem 3.3 *Every strongly g^*p-continuous function is continuous and thus pre-continuous and g^*p-continuous.*

Proof: The proof follows from the definitions.

The converse of the above theorem need not be true as seen from the following examples.

Example 3.4 *Let* $X = Y = \{a, b, c\}$, $\tau = \{X, \phi, \{a\}, \{a, c\}\}$ *and* $\sigma = \{X, \phi, \{a, b\}\}$. *Define a function* $f : X \to Y$ *by* $f(a) = a$, $f(b) = c$ *and* $f(c) = b$. *Then* f *is continuous but not strongly g^*p-continuous function, since for the g^*p-closed set* $\{a, b\}$ *in* Y, $f^{-1}(\{a, b\}) = \{a, c\}$ *is not closed in* X.

Example 3.5 *Let* X, Y, τ *and* σ *be as in Example 3.4, define a function* $f : X \to Y$ *by* $f(a) = b$, $f(b) = a$ *and* $f(c) = c$. *Then* f *is pre-continuous and g^*p-continuous but not strongly g^*p-continuous function, since for the g^*p-closed set* $\{c\}$ *in* Y, $f^{-1}(\{c\}) = \{c\}$ *is not closed in* X.

Theorem 3.6 *Every strongly continuous function is strongly g^*p-continuous but not conversely.*

Proof: The proof follows from the definitions.

Example 3.7 *Let* $X = Y = \{a, b, c\}$, $\tau = \{X, \phi, \{a\}, \{b\}, \{a, b\}, \{a, c\}\}$ *and* $\sigma = \{X, \phi, \{a\}\}$. *Then the identity function* $f : X \to Y$ *is strongly g^*p-continuous but not strongly continuous function, since for the subset* $\{b, c\}$ *in* Y, $f^{-1}(\{b, c\}) = \{b, c\}$ *is closed but not open in* X.

Theorem 3.8 *Every strongly g^*p-continuous is g^*p-irresolute and thus every strongly continuous map is g^*p-irresolute.*

Proof: Let $f : X \to Y$ be a strongly g^*p-continuous function and V be a g^*p-closed set in Y. Then $f^{-1}(V)$ is closed and hence g^*p-closed set in X from [19]. Hence f is g^*p-irresolute. By Theorem 3.6, f is g^*p-irresolute function.

The converse of the above theorem need not be true as seen from the following example.

Example 3.9 *Let* $X = Y = \{a, b, c\}$, $\tau = \{X, \phi, \{a, b\}\}$ *and* $\sigma = \{X, \phi, \{a\}, \{b\}, \{a, b\}\}$. *Define a function* $f : X \to Y$ *by* $f(a) = b$, $f(b) = a$ *and* $f(c) = c$. *Then* f *is g^*p-irresolute but not strongly g^*p-continuous function, since for the g^*p-closed set* $\{a, c\}$ *in* Y, $f^{-1}(\{a, c\}) = \{b, c\}$ *is not closed in* X.

Theorem 3.10 *Let (X, τ) be any topological space, (Y, σ) be a T_p^*-space and $f : X \to Y$ be a function. Then the following are equivalent:*
(1) f is strongly g^*p-continuous.
(2) f is continuous.

Proof: (1) $\Rightarrow$ (2): Follows from the Theorem 3.3.
(2) $\Rightarrow$ (1): Let U be any g^*p-open set in Y. Since (Y, σ) is T_p^*-space, U is open in (Y, σ). Again since f is continuous, we have $f^{-1}(U)$ is open in X. Therefore f is strongly g^*p-continuous.

Definition 3.11 *A topological space (X, τ) is called a g^*p-space if every subset in it is g^*p-closed. i.e. $g^*p(X, \tau) = P(X)$.*

Example 3.12 *Let $X = \{a, b, c\}$ and $\tau = \{X, \phi, \{a\}, \{b, c\}\}$. Then the space (X, τ) is g^*p-space, because $g^*p(X, \tau) = P(X)$.*

Theorem 3.13 *Let X be discrete topological space and Y be a g^*p-space and $f : X \to Y$ be a function. Then the following statements are equivalent:*
(1) f is strongly continuous.
(2) f is strongly g^*p-continuous.

Proof: (1) $\Rightarrow$ (2): Follows from the Theorem 3.6.
(2) $\Rightarrow$ (1): Let U be any g^*p-open set in Y. Since Y is g^*p-space, U is a g^*p-open subset of Y and by hypothesis, $f^{-1}(U)$ is open in X. But X is a discrete topological space and so $f^{-1}(U)$ is also closed in X. That is $f^{-1}(U)$ is both open and closed in X and hence f is strongly continuous.

Remark 3.14 *Strongly g^*p-continuity and strongly g-continuity are independent of each other as shown in the following examples.*

Example 3.15 *Let $X = Y = \{a, b, c\}$, $\tau = \{X, \phi, \{a\}, \{b\}, \{a, b\}\}$ and $\sigma = \{Y, \phi, \{a\}, \{a, b\}\}$. Define a function $f : X \to Y$ by $f(a) = b$, $f(b) = a$ and $f(c) = c$. Then f is strongly g-continuous but not strongly g^*p-continuous since for the g^*p-closed set $\{b\}$ in Y, $f^{-1}(\{b\}) = \{a\}$ is not closed in X.*

Example 3.16 *Let $X = Y = \{a, b, c\}$, $\tau = \{X, \phi, \{a\}, \{b\}, \{a, b\}, \{b, c\}\}$ and $\sigma = \{Y, \phi, \{a\}\}$. Define a map $f : X \to Y$ by $f(a) = b$, $f(b) = a$ and $f(c) = c$. Then f is strongly g^*p-continuous but not strongly g-continuous since for the g-closed set $\{a, b\}$ in Y, $f^{-1}(\{a, b\}) = \{a, b\}$ is not closed in X.*

Theorem 3.17 *The composition of two strongly g^*p-continuous functions is strongly g^*p-continuous function.*

Proof: Let $f : X \to Y$ and $g : Y \to Z$ be two strongly g^*p-continuous maps. Let V be a g^*p-closed set in Z. Since g is strongly g^*p-continuous, $g^{-1}(V)$ is closed in Y. Then $g^{-1}(V)$ is g^*p-closed in Y. Again since f is strongly g^*p-continuous, $f^{-1}(g^{-1}(V))$ is closed in X. That is $gof^{-1}(V)$ is closed in X. Hence gof is strongly g^*p-continuous.

Theorem 3.18 *Let $f : X \to Y$ and $g : Y \to Z$ be any two functions such that $gof : X \to Z$. Then*

1. *gof is strongly g^*p-continuous if g is strongly g^*p-continuous and f is continuous.*

2. *gof is g^*p-irresolute if g is strongly g^*p-continuous and f is g^*p-continuous (or f is g^*p-irresolute).*

3. *gof is continuous if g is continuous and f is strongly g^*p-continuous.*

Proof: The proof follows from the definitions.

Definition 3.19 *A function $f : X \to Y$ is called perfectly g^*-pre continuous (briefly perfectly g^*p-continuous) if the inverse image of every g^*p-closed set in Y is both open and closed in X.*

Theorem 3.20 *Every perfectly g^*p-continuous function is strongly g^*p-continuous but not conversely.*

Example 3.21 *In Example 3.7,the function f is strongly g^*p-continuous but not perfectly g^*p-continuous function, since for the g^*p - closed set $\{c\}$ in Y, $f^{-1}(\{c\}) = \{c\}$ is closed but not open in X.*

Theorem 3.22 *Every strongly continuous function is perfectly g^*p-continuous but not conversely.*

Example 3.23 *Let $X = Y = \{a, b, c\}$, $\tau = \{X, \phi, \{a\}, \{b\}, \{a, b\}, \{a, c\}\}$ and $\sigma = \{Y, \phi, \{a\}, \{a, b\}\}$. Define a function $f : X \to Y$ by $f(a) = b$, $f(b) = c$ and $f(c) = a$. Then f is perfectly g^*p-continuous but not strongly continuous, since for the subset $\{b\}$ in Y, $f^{-1}(\{b\}) = \{a\}$ is open but not closed in X.*

Theorem 3.24 *Let $f : X \to Y$ and $g : Y \to Z$ be any two functions such that $gof : X \to Z$. Then*

1. *gof is perfectly g^*p-continuous if f and g are perfectly g^*p-continuous functions.*

2. *gof is perfectly g^*p-continuous if f is perfectly g^*p-continuous and g is g^*p-irresolute.*

Proof: Straight forward.

Definition 3.25 *A function $f : X \to Y$ is called completely g^*-precontinuous (briefly completely g^*p-continuous) if the inverse image of every g^*p-closed set in Y is regular-closed in X.*

Theorem 3.26 *A function $f : X \to Y$ is completely g^*p-continuous if and only if the inverse image of every g^*p-open set in Y is regular-open in X.*

Theorem 3.27 *If a function $f : X \to Y$ is completely g^*p-continuous then f is continuous.*

The converse of the above theorem need not be true as seen from the following example.

Example 3.28 *Let $X = Y = \{a, b, c\}$, $\tau = \{X, \phi, \{a\}, \{a, b\}\}$ and $\sigma = \{Y, \phi, \{a, b\}\}$. Then the identity function $f : X \to Y$ is continuous but not completely g^*p-continuous.*

Theorem 3.29 *Every completely g^*p-continuous function is completely continuous but not conversely.*

Example 3.30 *Let $X = Y = \{a, b, c\}$, $\tau = \{X, \phi, \{a\}, \{b\}, \{a, b\}\}$ and $\sigma = \{Y, \phi, \{a\}\}$. Then the identity function $f : X \to Y$ is completely continuous but not completely g^*p-continuous since for the g^*p-open set $\{a, b\}$ in Y, $f^{-1}(\{a, b\}) = \{a, b\}$ is not regular-open in X.*

Theorem 3.31 *Every completely g^*p-continuous function is strongly g^*p-continuous but not conversely.*

Example 3.32 *In Example 3.7, the map f is strongly g^*p-continuous but not completely g^*p-continuous since for the g^*p-closed set $\{c\}$ in Y, $f^{-1}(\{c\}) = \{c\}$ is not regular-closed in X.*

Theorem 3.33 *If a map $f : X \to Y$ is completely continuous and Y is T_p^*-space, then f is completely g^*p-continuous.*

Theorem 3.34 *Let $f : X \to Y$ and $g : Y \to Z$ be any two functions such that $gof : X \to Z$. Then*

1. *gof is completely g^*p-continuous if f is completely continuous and g is completely g^*p-continuous.*

2. *gof is completely g^*p-continuous if f is completely g^*p-continuous and g is g^*p-irresolute.*

3. *gof is completely g^*p-continuous if f is completely g^*p-continuous and g is g^*p-continuous.*

Proof: Follows from the definitions.

4 Strongly g^*p-Closed Maps and Strongly g^*p-Open Maps

In this section, we introduce strongly g^*p-closed and strongly g^*p-open maps in topological spaces and investigate some of their properties.

Definition 4.1 *A map $f : X \to Y$ is called strongly g^*p-closed (resp. strongly g^*p-open) map if the image of every g^*p-closed (resp. g^*p-open) set in X is g^*p-closed (resp. g^*p-open) set in Y.*

Theorem 4.2 *If a map $f : X \to Y$ is strongly g^*p-closed then it is g^*p-closed.*

The converse of the above theorem need not be true as seen from the following example.

Example 4.3 *Let $X = Y = \{a, b, c\}$, $\tau = \{X, \phi, \{a\}, \{a, b\}\}$ and $\sigma = \{Y, \phi, \{a\}, \{b\}, \{a, b\}\}$. Then the identity map $f : X \to Y$ is g^*p-closed but not strongly g^*p-closed, since for the g^*p-closed set $\{b\}$ in X, $f(\{b\}) = \{b\}$ is not g^*p-closed in Y.*

Theorem 4.4 *The composition of two strongly g^*p-closed maps is again a strongly g^*p-closed map.*

Remark 4.5 *Strongly g^*p-closed maps and g^*p-irresolute maps are independent of each other as seen from the following examples.*

Example 4.6 *Let $X = Y = \{a, b, c\}$, $\tau = \{X, \phi, \{a\}, \{b\}, \{a, b\}\}$ and $\sigma = \{Y, \phi, \{a\}, \{a, c\}\}$. Define a map $f : X \to Y$ by $f(a) = a$, $f(b) = c$ and $f(c) = b$. Then f is strongly g^*p-closed but not g^*p-irresolute since for the g^*p-closed set $\{c\}$ in Y, $f(\{c\}) = \{b\}$ is not g^*p-closed in X.*

Example 4.7 *In Example 4.3, the map f is g^*p-irresolute but not strongly g^*p-closed map.*

Theorem 4.8 *A map $f : X \to Y$ is strongly g^*p-closed if and only if for each subset B of Y and for each g^*p-open set U of X containing $f^{-1}(B)$, there exists a g^*p-open set V of Y such that $B \subset V$ and $f^{-1}(V) \subset U$.*

Proof: Necessity: Suppose that f is a strongly g^*p-closed map. Let B be any subset of Y and U be a g^*p-open set of X containing $f^{-1}(B)$. Put $V = Y - f(X - U)$. Then V is a g^*p-open set in Y containing B such that $f^{-1}(V) \subset U$.

Sufficiency: Let F be any g^*p-closed subset of X. Then $f^{-1}(Y - f(F)) \subset X - F$. Put $B = Y - f(F)$. We have $f^{-1}(B) \subset X - F$. Also $X - F$ is g^*p-open in X and $f^{-1}(V) \subset X - F$. Therefore we have $f(F) = Y - V$ and hence $f(F)$ is g^*p-closed in Y. Therefore f is strongly g^*p-closed map.

Theorem 4.9 *If $f : X \to Y$ is g-irresolute and M-preclosed, then f is strongly g^*p-closed map.*

Proof: Let A be a g^*p-closed set in X. Let V be any g-open set in Y containing $f(A)$. Then $A \subset f^{-1}(V)$. Since f is g-irresolute, $f^{-1}(V)$ is g-open set in X. Again since A is g^*p-closed in X, $pcl(A) \subset f^{-1}(V)$ and hence $f(A) \subset f(pcl(A)) \subset V$. As f is M-preclosed and $pcl(A)$ is preclosed in X, $f(pcl(A))$ is preclosed in Y and hence $pcl(f(A)) \subset pcl(f(pcl(A))) \subset V$. This shows that $f(A)$ is g^*p-closed set in Y. Hence f is strongly g^*p-closed.

Theorem 4.10 *Let $f : X \to Y$ and $g : Y \to Z$ be two maps such that $gof : X \to Z$. Then*
(1) gof is g^*p-closed if f is closed and g is strongly g^*p-closed.
(2) gof is g^*p-closed if f is closed and g is g-irresolute and M-preclosed.
(3) g is g^*p-closed if f is continuous surjections and gof is strongly g^*p-closed.

Proof: (1) By Theorem 4.2, g is g^*p-closed map. Let K be a closed set in X. Since f is closed, then $f(K)$ is closed in Y. Therefore $g(f(K))$ is g^*p-closed in Z as g is g^*p-closed map. That is $gof(K)$ is g^*p-closed set in Z. Hence gof is g^*p-closed map.

(2). By Theorem 4.9, g is strongly g^*p-closed map. Hence by (1), gof is g^*p-closed.

(3). Let F be a closed set of Y. Since f is continuous, $f^{-1}(F)$ is closed in X and hence $f^{-1}(F)$ is g^*p-closed in X. Since gof is strongly g^*p-closed, $(gof)(f^{-1}(F))$ is g^*p-closed in Z. Again since f is surjective, $g(F)$ is g^*p-closed in Z. Hence g is g^*p-closed.

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References

[1] D. Andrijevic, Semi-preopen sets, *Mat Versnik*, 38(1) (1986), 24-32.

[2] S.P. Arya and R. Gupta, On strongly continuous mappings, *Kyungpook Math. Jl.*, 14(1974), 131-143.

[3] K. Balachandran, P. Sundaram and H. Maki, On generalized continuous maps in topological spaces, *Mem. Fac. Sci. Kochi Univ. Ser. A. Math.*, 74(1972), 233-254.

[4] S.G. Crossely and S.K. Hildebrand, Semi-topological properties, *Fund. Math.*, 12(1991), 5-13.

[5] R. Devi, K. Balachandran and H. Maki, Semi-generalized closed maps and generalized semi-closed maps, *Mem. Fac. Sci. Kochi Univ. Ser. A. Math.*, 14(1993), 41-54.

[6] N. Levine, Strong continuity in topological spaces, *Amer. Math. Monthly*, 67(1960), 269-279.

[7] N. Levine, Semi-open sets and semi-continuity in topological spaces, *Amer. Math. Monthly*, 70(1963), 36-41.

[8] N. Levine, Generalized closed sets in topology, *Rend. Circ. Mat. Palermo*, 19(2) (1969), 89-96.

[9] H. Maki, P. Sundaram and K. Balachandran, On generalized homeomorphisms in topological spaces, *Bull. Fukuoka Univ. Ed. Part III*, 40(1991), 13-21.

[10] H. Maki, J. Umehara and T. Noiri, Every topological space is pre-$T_{1/2}$, *Mem. Fac. Sci. Kochi Univ. Ser. A. Math.*, 17(1996), 33-42.

[11] S.R. Malghan, Generalized closed maps, *J. Karnataka Univ. Sci.*, 27(1982), 82-88.

[12] A.S. Mashhour, M.E.A. El-Monsef and S.N. El-Deeb, On pre continuous and weak pre continuous mappings, *Proc. Math. And Phys. Soc. Egypt*, 53(1982), 47-53.

[13] A.S. Mashhour, A. Hasanein and S.N. El-Deeb, α -continuous and α-open mappings, *Acta math. Hung.*, 41(3-4) (1983), 213-218.

[14] A.S. Mashhour, M.E.A. El-Monsef and S.N. El-Deeb, On pre topological spaces, *Bull. Mathe. de la Soc.Sc. Math. de la R. S. de Roumanie Tome.*, 28(76) (1984),39-45.

[15] O. Njastad, On some classes of nearly open sets, *Pacific Jl. Math.*, 15(1965), 961-970.

[16] T. Noiri, Super continuity and some strong forms of continuity, *Indian Jl. Pure Appl. Math.*, 15(1984), 241-250.

[17] P.G. Patil, T.D. Rayanagoudar and S.S. Benchalli, Generalization of new continuous functions in topological spaces, *CUBO A Mathematical Journal.*, 15(3) (2013), 69-76.

[18] P. Sundaram, Studies on generalizations of closed sets and continuous maps in topological spaces, *Ph.D. Thesis*, Bharathiar University, Coimbatore, (1991).

[19] M.K.R.S. Veerakumar, g^*-preclosed sets, *Acta Ciencia Indica*, 28(1) (2002), 51-60.