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$\mathcal{C}$ mαg CONTINUOUS FUNCTION IN TOPOLOGICAL SPACES

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Abstract: In this paper, we introduce and investigate a new class of mappings namely contra mildly α generalized continuous (briefly $\mathcal{C}$ mαg continuous) maps and discuss their relation between few existing contra continuous maps.

Keywords and Phrases: $\mathcal{C}$ mαg continuous functions, mαg irresolute maps.

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1. Introduction and Preliminaries

In 1996, Dontchev [3] introduced a new notion of contra continuity. In 1999 J. Dontchev and Noiri [4] introduced and investigated contra semi-continuous functions. In 2001 S. Jafari and T. Noiri [5] introduced contra α continuous functions between topological spaces. Also in 2002 Jafari.et.al [6] introduced contra pre-continuous functions. In this paper, we apply the concept of contra continuity to mildly α generalized closed sets. Preliminaries

Throughout this paper, (X, τ), (Y, σ) and (Z, η) (or simply X, Y and Z) always denote topological spaces on which no separation axioms are assumed unless otherwise mentioned. For a subset A of a space X, $cl(A)$ and $int(A)$ denote the closure

of A and the interior of A respectively. $X\ A$ or A^c denotes the complement of A in X.

Throughout this paper mildly α generalized closed sets are denoted as mαg closed sets and we denote contra mildly α generalized continuous maps as $\mathcal{C}$ mαg continuous maps. We recall the following definitions and results.

Definition 1.1. *A subset A of a topological space $(X, \tau$ is called*
(i) a semi-open set [12] if $A \subseteq cl(int(A))$ and semi-closed set if $int(cl(A)) \subseteq A$,
(ii) a pre-open set [13] if $A \subseteq int(cl(A))$ and pre-closed set if $cl(int(A)) \subseteq A$,
(iii) a regular open set [15] if $A = int(cl(A))$ and a regular closed set if $A = cl(int(A))$,
(iv) a α-open set [7] if $A \subseteq int(cl(int(A)))$ and α-closed set if $cl(int(cl(A))) \subseteq A$,
(v) a semi-pre open set [1] ($= \beta$-open [1] if $A \subseteq cl(int(cl(A))))$ and a semi-pre closed set ($= \beta$-closed) if $int(cl(int(A))) \subseteq A$.

Definition 1.2. *A subset A of a topological space (X, τ) is called*
(i) generalized (g) closed [4] if $cl(A) \subseteq U$ whenever $A \subseteq U$ and U is open in X.
(ii) weakly generalized (wg) closed [14] if $cl(int(A)) \subseteq U$ whenever $A \subseteq U$ and U is open in X.
(iii) mildly generalized (mg) closed [16] if $cl(int(A)) \subseteq U$ whenever $A \subseteq U$ and U is g-open in X.
(iv) α-generalized (αg) closed [2] if $\alpha cl(A) \subseteq U$ whenever $A \subseteq U$ and U is open in X.
(v) regular generalized (rg) closed [15] if $cl(A) \subseteq U$ whenever $A \subseteq U$ and $U$is regular open in X.
(vi) regular mildly generalized (RMG) closed [18] if $cl(int(A)) \subseteq U$ whenever $A \subseteq U$ and U is regular generalized open set in X.
(vii) mildly α-generalized $(m\alpha g)$ closed [9] if $cl(int(A)) \subseteq U$ whenever $A \subseteq U$ and U is αg-open in X.

Definition 1.3. *A function $f : (X, \tau) \to (Y, \sigma)$ is called a*
(i) continuous [10] if $f^{-1}(V)$ is closed in X for every closed subset V of Y.
(ii) mαg continuous [10] if and only if $f^{-1}(V)$ is mαg closed in X for every closed set V of (Y, σ).

Definition 1.4. *A map $f : (X, \tau) \to (Y, \sigma)$ is said to be perfectly-continuous [11] if $f^{-1}(V)$ is clopen in X for every open set V in Y.*

Definition 1.5. *A map $f : (X, \tau) \to (Y, \sigma)$ is called perfectly mαg continuous [12] if the inverse image of every mαg open set in (Y, σ) is clopen in (X, τ).*

Definition 1.6. *A function $f : (X, \tau) \to (Y, \sigma)$ is called a mαg irresolute map*

[10] if the inverse image $f^{-1}(V)$ is $m\alpha g$ closed set in X for every $m\alpha g$ closed set V in Y.

Definition 1.7. *A function $f : (X, \tau) \to (Y, \sigma)$ is called a*
(i) Contra-continuous [3] if $f^{-1}(V)$ is closed in (X, τ) for every open set V in (Y, σ).
(ii) Contra pre-continuous [6] if $f^{-1}(V)$ is pre-closed in (X, τ) for every open set V in (Y, σ).
(iii) Contra-α-continuous [5] if $f^{-1}(V)$ is α-closed in (X, τ) for every open set V in (Y, σ).
(iv) Contra-g-continuous [2] if $f^{-1}(V)$ is g-closed in (X, τ) for every open set V in (Y, σ).
(v) Contra rg-continuous [18] if $f^{-1}(V)$ is rg-closed in (X, τ) for every open set V in (Y, σ).
(vi) Contra wg-continuous [18] if $f^{-1}(V)$ is wg-closed in (X, τ) for every open set V in (Y, σ).
(vii) Contra rwg-continuous [18] if $f^{-1}(V)$ is rwg-closed in (X, τ) for every open set V in (Y, σ).
(viii) Contra g$*$-continuous [18] if $f^{-1}(V)$ is g$*$ closed in (X, τ) for every open set V in (Y, σ).
(ix) Contra mildly g-continuous [18] if $f^{-1}(V)$ is mildly g-closed in (X, τ) for every open set V in (Y, σ).
(x) Contra RMG-continuous [18] if $f^{-1}(V)$ is RMG-closed in (X, τ) for every open set V in (Y, σ).

2. Contra mildly α-generalized continuous maps

The concept of $\mathcal{C}$ $m\alpha g$ continuous functions in topological spaces is introduced in this section. We study their relations with various contra continuous functions and also discuss some properties of $\mathcal{C}$ $m\alpha g$ continuous functions.

Definition 2.1. *A function $f : (X, \tau) \to (Y, \sigma)$ is contra mildly α-generalized $(\mathcal{C}m\alpha g)$ continuous if and only if $f^{-1}(V)$ is $m\alpha g$ closed in X for every open set V of (Y, σ).*

Theorem 2.2. *Every contra continuous function is $(\mathcal{C}m\alpha g)$ continuous.*
Proof. Let $f : (X, \tau) \to (Y, \sigma)$ be contra continuous map. Let us consider an open set G in Y. Since the mapping 'f' is contra continuous, $f^{-1}(G)$ is closed in (X, τ). By [9], every closed set in (X, τ) is $m\alpha g$ closed set in (X, τ). Therefore the mapping 'f' is $(\mathcal{C}m\alpha g)$ continuous.

Remark 2.3. *The converse of the above theorem need not be true as seen from the*

following example.

Example 2.4. Let $X = Ya, b, c$ and $\tau = \{\varphi, \{c\}, \{b, c\}, X\}$ and $\sigma = \{Y, \varphi, \{a\}, \{a, b\}\}$. Define a identity map $f : (X, \tau) \to (Y, \sigma)$ by $f(a) = a,\ f(b) = b,\ f(c) = c$. Then f is $(\mathcal{C}m\alpha g)$ continuous but not continuous, since for the open set b in (Y, σ), $f^{-1}\{b\} = \{b\}$ is not closed in (X, τ).

Theorem 2.5. *(i) If a function $f : (X, \tau) \to (Y, \sigma)$ is contra - pre continuous then it is $(\mathcal{C}m\alpha g)$ continuous. (ii) If a function $f : (X, \tau) \to (Y, \sigma)$ is contra -α-continuous then it is $(\mathcal{C}m\alpha g)$ continuous.*

Proof. (i). Let B be an open set in Y. Suppose 'f' is contra pre continuous function, then $f^{-1}(B)$ is pre closed set in X. By [9] every preclosed set is $m\alpha g$) closed in X. Hence $f^{-1}(B)$ is $m\alpha g$) closed in X. Therefore mapping 'f' is $(\mathcal{C}m\alpha g)$ continuous.

(ii). Suppose 'f' is contra α-continuous function, V be any open set in Y. As the map 'f' is contra α- continuous, then $f^{-1}(V)$ is α-closed set in X. By [9] every α-closed set is $m\alpha g$) closed in X. Hence 'f' is $(\mathcal{C}m\alpha g)$ continuous.

Remark 2.6. *The converse of the above theorem is not true as shown in the following example.*

Example 2.7. Let $X = \{a, b, c\}$ and $\tau = \{\varphi, \{c\}, \{a, b\}, X\},\ Y = \{1, 2, 3\},\ \sigma = \{Y, \varphi, \{3\}, \{2, 3\}\}$. Define a map $f : (X, \tau) \to (Y, \sigma)$ by $f(a) = 1,\ f(b) = 2,\ f(c) = 3$. Then f is $(\mathcal{C}m\alpha g)$ continuous but not contra pre-continuous, contra α-continuous since for the open set $\{3\}$ in (Y, σ), $f^{-1}\{3\} = \{c\}$ is not preclosed in (X, τ), And also for the open set $\{2, 3\}$ in (Y, σ), $f^{-1}\{2, 3\} = \{b, c\}$ is not α-closed set in (X, τ) but $m\alpha g$) closed set in (X, τ).

Theorem 2.8. *(i).If a function $f : (X, \tau) \to (Y, \sigma)$ is $(\mathcal{C}m\alpha g)$ continuous, then it is contra mg continuous.*

(ii).If a function $f : (X, \tau) \to (Y, \sigma)$ is $(\mathcal{C}m\alpha g)$ continuous, then it is contra wg continuous.

Proof. (i). Let G be an open set in Y. Suppose 'f' is $(\mathcal{C}m\alpha g)$ continuous function, then $f^{-1}(G)$ is $m\alpha g$ closed set in X. By [9] every $m\alpha g$) closed set is mg closed in X. Hence $f^{-1}(G)$ is mg closed in X. Therefore mapping 'f' is contra mg continuous.

(ii). Suppose 'f' is $(\mathcal{C}m\alpha g)$ continuous function, V be any open set in Y. As the map 'f' is $(\mathcal{C}m\alpha g)$ continuous, then $f^{-1}(V)$ is $m\alpha g$ closed set in X. By [9], every $m\alpha g$ closed set is wg closed in X. Hence 'f' is contra wg continuous.

Remark 2.9. *The converse of the above theorem is not true as shown in the following example.*

Example 2.10. Let $X = \{a, b, c, d\} = Y$ and $\tau = \{\varphi, \{a\}, \{a, b, c\}, X\}$, $\sigma = \{Y, \varphi, \{b, c\}, \{a, d\}\}$. Define a map $f : (X, \tau) \to (Y, \sigma)$ by $f(a) = a$, $f(b) = b$, $f(c) = c$. Then f is not $(\mathcal{C}m\alpha g)$ continuous but it is contra- mg continuous and contra-wg continuous, since for the open set $\{a, d\}$ in (Y, σ), $f^{-1}\{a, d\} = \{a, d\}$ is not $m\alpha g$ closed in (X, τ).

Remark 2.11. *The concept of* $(\mathcal{C}m\alpha g)$ *continuous is independent from the concept of contra -g continuous, contra RMG-continuous, contra RW-continuous, contra* rg*-continuous, contra* $g*$*-continuous.*

Example 2.12. Let $X = \{a, b, c\} = Y$ and $\tau = \{\varphi, \{c\}\{b\}, \{a, b\}, \{b, c\}X\}$, $\sigma = \{Y, \varphi, \{c\}, \{a, c\}, \{b, c\}\}$, Define a map $f : (X, \tau) \to (Y, \sigma)$ by $f(a) = a$, $f(b) = b$, $f(c) = c$. Then f is contra rg-continuous but not $(\mathcal{C}m\alpha g)$ continuous, since for the open set $\{b, c\}$ in (Y, σ), $f^{-1}\{b, c\} = \{b, c\}$ is not $m\alpha g$ closed in (X, τ).

Example 2.13. Let $X = \{a, b, c, d\} = Y$ and $\tau = \{\varphi, \{a\}\{b\}, \{a, b\}, \{a, b, c\}X\}$, $\sigma = \{Y, \varphi, \{a\}, \{b\}, \{a, b\}, \{a, c\}, \{a, b, c\}\}$, Define a map $f : (X, \tau) \to (Y, \sigma)$ by $f(a) = c$, $f(b) = b$, $f(c) = a$, $f(d) = d$. Then f is $(\mathcal{C}m\alpha g)$ continuous but not contra-rg continuous, since for the open set $\{a\}$ in (Y, σ), $f^{-1}\{a\} = \{c\}$ is not rg closed in (X, τ).

Example 2.14. Let $X = \{a, b, c\} = Y$ and $\tau = \{\varphi, \{c\}\{a, c\}\{b, c\}X\}$, $\sigma = \{Y, \varphi, \{a\}, \{b, c\}\}$, Define a map $f : (X, \tau) \to (Y, \sigma)$ by $f(a) = a$, $f(b) = b$, $f(c) = c$. Then f is contra RMG-continuous but not $(\mathcal{C}m\alpha g)$ continuous, since for the open set $\{a\}$ in (Y, σ), $f^{-1}\{a\} = \{c\}$ is not $m\alpha g$ closed in (X, τ).

Example 2.15. Let $X = \{a, b, c\} = Y$ and $\tau = \{\varphi, \{c\}, \{b, c\}X\}$, $\sigma = \{Y, \varphi, \{a\}, \{a, c\}\}$, Define a map $f : (X, \tau) \to (Y, \sigma)$ by $f(a) = a$, $f(b) = b$, $f(c) = c$. Then f is $(\mathcal{C}m\alpha g)$ continuous but not contra- RMG continuous, since for the open set $\{a, c\}$ in (Y, σ), $f^{-1}\{a, c\} = \{a, c\}$ is not RMG closed in (X, τ).

Example 2.16. Let $X = \{a, b, c, d\} = Y$ and $\tau = \{\varphi, \{a\}, X\}$, $\sigma = \{Y, \varphi, \{a, b, c\}\}$, Define a map $f : (X, \tau) \to (Y, \sigma)$ by $f(a) = c$, $f(b) = b$, $f(c) = a$, $f(d) = d$. Then f is contra g -continuous but not $(\mathcal{C}m\alpha g)$ continuous, since for the open set $\{a, b, c\}$ in (Y, σ), $f^{-1}\{a, b, c\} = \{a, b, c\}$ is not $m\alpha g$ closed in (X, τ).

Example 2.17. Let $X = \{a, b, c, d\} = Y$ and $\tau = \{\varphi, \{a, b, c\}, X\}, \sigma = \{Y, \varphi, \{a, b\}\}$, Define a map $f : (X, \tau) \to (Y, \sigma)$ by $f(a) = c$, $f(b) = b$, $f(c) = a$, $f(d) = d$. Then f is contra g -continuous but not $(\mathcal{C}m\alpha g)$ continuous, since for the open set $\{a, b\}$ in (Y, σ), $f^{-1}\{a, b\} = \{a, b\}$ is not $m\alpha g$ closed in (X, τ).

Example 2.18. Let $X = \{a, b, c\} = Y$ and $\tau = \{\varphi, \{c\}, \{a, b\}, X\}$, $\sigma = \{Y, \varphi, \{a\}, \{a, b\}\}$, Define a map $f : (X, \tau) \to (Y, \sigma)$ by $f(a) = a$, $f(b) = b$, $f(c) = c$. Then f is $(\mathcal{C}m\alpha g)$ continuous but not contra- $g*$ continuous, since for the open set $\{a\}$ in (Y, σ), $f^{-1}\{a\} = \{a\}$ is not $g*$ -closed in (X, τ).

Example 2.19. Let $X = \{a, b, c\} = Y$ and $\tau = \{\varphi, \{a\}, X\}$, $\sigma = \{Y, \varphi, \{c\}, \{a, c\}\}$,

Define a map $f : (X, \tau) \to (Y, \sigma)$ by $f(a) = a,\ f(b) = b,\ f(c) = c$. Then f is contra $g*$-continuous but not$(\mathcal{C}m\alpha g)$ continuous, since for the open set $\{a, c\}$ in $(Y, \sigma),\ f^{-1}\{a, c\} = \{a, c\}$ is not αg closed in (X, τ).

Remark 2.20. *The composition of two $(\mathcal{C}m\alpha g)$ continuous maps need not be $(\mathcal{C}m\alpha g)$ continuous.*

Example 2.21. Let $X = Y = Z = \{a, b, c\}$. With $(X, \tau) = \{\varphi, \{c\}, \{b, c\}, X\}$, $(Y, \sigma) = \{\varphi, \{a\}, \{b\}, \{a, b\}, Y\},\ (Z, \eta) = \{\varphi, \{c\}, \{a, c\}, \{b, c\}, Z\}$. Define a map $f : (X, \tau) \to (Y, \sigma)$ by $f(a) = (a),\ f(b) = (b),\ f(c) = (c)$. Define a map $g : (Y, \sigma) \to (Z, \eta)$ by $g(a) = (a),\ g(b) = (b),\ g(c) = (c)$. Here $\{b, c\}$ is open set in (Z, η), but $(gof)^{-1}\{b, c\} = \{b, c\}$ is not $m\alpha g$ closed in (X, τ). Hence the composition mapping fails in $(\mathcal{C}m\alpha g)$ continuous map.

Theorem 2.22. *If $f : (X, \tau) \to (Y, \sigma)$ is $(\mathcal{C}m\alpha g)$ continuous and $g : (Y, \sigma) \to (Z, \eta)$ is continuous, then their composition $gof : (X, \tau) \to (Z, \eta)$ is $(\mathcal{C}m\alpha g)$ continuous.*

Proof. Let V be any open set in (X, τ), the mapping $g : (Y, \tau) \to (Z, \eta)$ is continuous, $g^{-1}(V)$ is open in (Y, σ), then $f^{-1}(g^{-1}(V)$ is closed in (X, τ). Since f is $(\mathcal{C}m\alpha g)$ continuous, for an open set in (Y, σ) it is $m\alpha g$ closed in (X, τ). Hence gof is $(\mathcal{C}m\alpha g)$ continuous.

Theorem 2.23. *Let $f : (X, \tau) \to (Y, \sigma)$ be map, then the following are equivalent.*
i) f is $(\mathcal{C}m\alpha g)$ continuous.
ii) The inverse image of each closed set F of Y is $m\alpha g$ open in X.
iii) The inverse image of each open set U of Y is $m\alpha g$ closed in X.

Proof. Suppose i) hold. Let F be a closed set in Y. Then $Y - F$ is open set in Y. By (i), $f?1(Y?F) = X - f^{-1}(F)$ is $m\alpha g$ closed in X. Therefore $f^{-1}(U)$ is $m\alpha g$ open in X. This proves (i) $\Rightarrow$ (ii). The implications (ii) $\Rightarrow$ (iii) and (iii) $\Rightarrow$(i) obviously.

Theorem 2.24. *Let $f : (X, \tau) \to (Y, \sigma)$ be a function and X is a $m\alpha g$ space. Then the following are equivalent.*
i) f is contra-continuous. ii) f is $\mathcal{C}$ $m\alpha g$ continuous.

Proof. $(i) \Rightarrow (ii)$: Let U be any open set in (Y, σ). Since f is contra continuous, $f^{-1}(U)$ is closed in (X, τ) and since every closed set is $m\alpha g$ closed, $f^{-1}(U)$ is $m\alpha g$ closed in (X, τ). Therefore f is $\mathcal{C}$ $m\alpha g$ continuous.
$(ii) \Rightarrow (i)$: Let U be any open set in (Y, σ). Since f is $\mathcal{C}$ $m\alpha g$ continuous, $f^{-1}(U)$ is $m\alpha g$ -closed in (X, τ) and since X is a $m\alpha g$ space, $f^{-1}(U)$ is closed in (X, τ). Therefore f is contra-continuous.

Theorem 2.25. *Let $f : (X, \tau) \to (Y, \sigma)$ and $g : (Y, \sigma) \to (Z, \eta)$ be any two functions. Then*
(i). $gof : (X, \tau) \to (Z, \eta)$ is $\mathcal{C}$ $m\alpha g$ continuous if g is $\mathcal{C}$ $m\alpha g$ continuous and f is

$m\alpha g$ -irresolute.
(ii). $gof : (X, \tau) \to (Z, \eta)$ is $\mathcal{C}$ $m\alpha g$ continuous if g is continuous and f is contra pre-continuous.
(iii). $gof : (X, \tau) \to (Z, \eta)$ is perfectly $m\alpha g$ continuous if g is $\mathcal{C}$ $m\alpha g$ continuous and f is perfectly RMG continuous.

Proof. (i) Let U be an open set in (Z, η). Since g is $\mathcal{C}$ $m\alpha g$ continuous, then $g^{-1}(U)$ is $m\alpha g$ closed set in (Y, σ). Since f is $m\alpha g$ irresolute, $f^{-1}(g^{-1}(U))$ is an $m\alpha g$ closed set in (X, τ). Thus $(gof)^{-1}(U) = f^{-1}(g^{-1}(U))$ is an $m\alpha g$ closed set in (X, τ). Therefore gof is $\mathcal{C}$ $m\alpha g$ continuous.
(ii) Let U be an open set in (Z, η). Since g is continuous, $g^{-1}(U)$ is open set in (Y, σ). Since f is contra precontinuous then $f^{-1}(g^{-1}(U))$ is an pre-closed set in (X, τ). Hence by [9], every pre-closed set is $m\alpha g$ closed, $(gof)^{-1}(U) = f^{-1}(g^{-1}(U))$ is an $m\alpha g$ closed set in (X, τ). Therefore gof is $\mathcal{C}$ $m\alpha g$ continuous.
(iii) Let U be a open set in (Z, η). By [9] every open set is $m\alpha g$ open which implies U is $m\alpha g$ open in (Z, η). Since g is $\mathcal{C}$ $m\alpha g$ continuous, then $g^{-1}(U)$ is $m\alpha g$ closed set in (Y, σ). Since f is perfectly $m\alpha g$ continuous, $f^{-1}(g^{-1}(U))$ is both open and closed set in (X, τ). Thus $(gof)^{-1}(U) = f^{-1}(g^{-1}(U))$ is both open and closed set in (X, τ). Therefore gof is perfectly $m\alpha g$ continuous.

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