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# (r*g*)* CONTINUOUS MAPS IN TOPOLOGICAL SPACES

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**ABSTRACT**

*The aim of this paper is to introduce (r*g*)* continuous functions and study some of the properties.*



## INTRODUCTION

N Levine [8] introduced the class of semi continuous functions using semi open sets. Balachandran et al in[2]introduced the concept of generalized continuous maps in a topological space. Many authors introduced several generalized closed sets and generalized continuous maps. The Authors [11] have already introduced (r*g*)* closed sets and investigated some of their properties. In this paper we introduce a new class of maps called (r*g*)* continuous maps. Also (r*g*)* irresolute map is introduced.

### Priliminaries

**Definition: 2.1** A subset A of a space X is called

1. A generalized closed (g closed) [7] set if cl(A) ⊆ U whenever A ⊆ U and U is open.
2. A Regular generalized closed (rg-closed) [15 ] set if cl(A) ⊆ U whenever A ⊆ U and U is regular open.
3. A generalized pre regular closed (gpr closed)[6] if pcl(A) ⊆ U whenever A ⊆ U and U is regular open.
4. A g* closed [18] if cl(A) ⊆ U whenever A ⊆ U and U is g-open.
5. A regular weakly generalized semi closed (rwg closed) [12] if cl (int(A)) ⊆ U whenever A ⊆ U and U is regular open.
6. A g**closed[14] if cl(A) ⊆ U whenever A ⊆ U and U is g*-open.

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7. A g# closed [17] if cl(A) $\subseteq$ U whenever A $\subseteq$ U and U is $\alpha$ g open.
8. A generalized semi-preclosed star closed ((gsp)* closed)[13] if cl(A) $\subseteq$ U whenever A $\subseteq$ U and U is gsp open.
9. A gp* closed [7] if cl(A) $\subseteq$ U whenever A $\subseteq$ U and U is gp-open.
10. A regular^ generalized closed (r^g closed)[16] if gcl(A) $\subseteq$ U whenever A $\subseteq$ U and U is regular open.
11. A regular generalized b-closed (rgb closed) [9] if bcl(A) $\subseteq$ U whenever A $\subseteq$ U and U is regular open.
12. A ( r*g*)*closed set [11] if cl(A) $\subseteq$ U whenever A $\subseteq$ U and U is r*g*- open.

**Definition 2.2:** A function f : (X τ) $\rightarrow (Y,\sigma)$ is said to be

(i) rg- continuous [15 ] if $f^{1}$(V) is rg closed in ( X,τ) for every closed set V of (Y,σ).
(ii) gpr- continuous [ 6 ] if $f^{1}$(V) is gpr closed in ( X,τ) for every closed set V of (Y,σ).
(iii) rwg continuous [ 12 ] if $f^{1}$(V) is rwg closed in ( X,τ) for every closed set V of (Y,σ).
(iv) r^g continuous [ 16 ] if $f^{1}$(V) is r^g closed in ( X,τ) for every closed set V of (Y,σ).
(v) rgb continuous [9 ] if $f^{1}$(V) is rgb closed in ( X,τ) for every closed set V of (Y,σ).
(vi) g* continuous [ 18 ] if $f^{1}$(V) is g* closed in ( X,τ) for every closed set V of (Y,σ).
(vii) g**continuous [ 14 ] if $f^{1}$(V) is g** closed in ( X,τ) for every closed set V of (Y,σ).
(viii) g# continuous [ 17 ] if $f^{1}$(V) is g# closed in ( X,τ) for every closed set V of (Y,σ).
(ix) (gsp)* continuous [13] if $f^{1}$(V) is (gsp)* closed in ( X,τ) for every closed set V of (Y,σ).
(x) (gp)*- continuous [7 ]if $f^{1}$(V) is (gp)* closed in ( X,τ) for every closed set V of (Y,σ).

## 3. (r*g*)* -CONTINUOUS AND IRRESOLUTE MAPS

**Definition 3.1:** A map f : (X, $\tau$) → (Y, $\sigma$) is called (r*g*)*-continuous if the inverse image of every closed set in (Y, $\sigma$) is (r*g*)*-closed in (X, $\tau$).

**Theorem 3.2:**

Every continuous map is (r*g*)*-continuous.

**Proof:** Let f : (X, $\tau$) → (Y, $\sigma$) be a continuous map . Let F be a closed set in (Y, $\sigma$)**.** Then $f^{-1}(F)$ is closed in (X, $\tau$).Since every closed set is (r*g*)*-closed ⇒ $f^{-1}(F)$ is (r*g*)*-closed set.Therefore f is (r*g*)*-continuous.

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

**Example 3.3**

Let X ={a,b,c} $\tau$ = { $\phi$,X, {c},{b,c}} Closed set of X = { $\phi$,X,{a,b},{a}}
(r*g*)* closed sets are { $\phi$,X, {a},{a,b},{a,c}}
Let Y ={a,b,c} , $\sigma$ = { $\phi$,Y, {b}} Closed set of Y = { $\phi$,Y,{a,c}}

Let f be the identity mapping .{a,c} is closed in (Y, $\sigma$).Now $f^{1}${a,c}={a,c} is not closed in (X, $\tau$) Hence f is not continuous. But {a,c} is (r*g*)*closed set. Therefore f is (r*g*)* continuous.

**Theorem:3.4**

Every (r*g*)*-continuous map is rg-continuous**.**

**Proof :** Let f : (X, $\tau$) → (Y, $\sigma$) be a (r*g*)*-continuous map . Let V be a closed set in (Y, $\sigma$)**.**

Since f is (r*g*)*-continuous, $f^{-1}$ (V) is (r*g*)*-closed in (X, $\tau$). By proposition 3.7[11]

$f^{-1}$ (V) is rg-closed in (X, $\tau$).Therefore, f is rg-continuous.

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

**Example:3.5**

Let X ={a,b,c} $\tau$ = { $\phi$,X,{a},{b} {a,b}} Closed set of X = { $\phi$,X,{b,c},{a,c},{c}}
(r*g*)* closed sets are { $\phi$,X, {c},{,b,c},{a,c}}

Let Y ={a,b,c} , $\sigma$ = { $\phi$,Y, {c}}, Closed set of Y = { $\phi$,Y,{a,b}}

Let f be defined as f(a)=b , f(b)=a , f(c)=c. Now {a,b} is closed in Y.

Now $f^{-1}${a,b}={a,b} is rg closed in (X, $\tau$) Hence f is rg continuous. But{a,b}is not (r*g*)*closed set. Therefore f is not (r*g*)* continuous.

**Theorem 3.6**

Every (r*g*)*-continuous map is gpr-continuous.

**Proof** : Follows from proposition 3.9 [11].

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

**Example:3.7**

Let X ={a,b,c} $\tau$ = { $\phi$,X, {a,b}} Closed set of X = { $\phi$,X,{b,c}}

(r*g*)* closed sets are { $\phi$,X, {c},{,b,c},{a,c}}

Let Y ={a,b,c} , $\sigma$ = { $\phi$,Y, {b,c}} Closed set of Y = { $\phi$,Y,{a}}

f : (X, $\tau$) → (Y, $\sigma$) be the map and Let f(a)=a , f(b)=c , f(c)=b.

Now {a} is closed in Y. But $f^{-1}${a}={a} is gpr closed but not (r*g*)* closed in (X,τ).Hence f is gpr continuous but not (r*g*)* continuous.

**Theorem 3.8**

Every (r*g*)*-continuous map is rwg-continuous

**Proof**: Follows from proposition 3.11 [11].

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

**Example: 3.9**

Let X =Y={a,b,c} , $\tau$ = { $\phi$,X, {a,b}}, (r*g*)* closed sets are { $\phi$,X, {c},{,b,c},{a,c}} **,** $\sigma$ ={ $\phi$ , Y,{,a,c}}. Closed set of Y = {$\phi$,Y,{b}} f : (X, $\tau$) → (Y, $\sigma$) is defined by f(a) =b ,f(b) =c , f(c) =a. Then $f^{-1}${b}={a} is not (r*g*)*-closed in (X, $\tau$). But {a} is rwg-closed .Hence f is rwg continuous but not (r*g*)* continuous.

**Theorem 3.10**

Every (r*g*)*-continuous map is r^g-continuous

**Proof** : Follows from proposition 3.21 [11].

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

**Example:3.11**

Let X =Y={a,b,c}, $\tau$ = {$\phi$,X,{a},{b}, {a,b}}, (r*g*)* closed sets of X are φ,X,{c},{b,c},{a,c}. $\sigma$ ={$\phi$, Y,{c}}. σ closed sets are $\phi$ , Y,{a,b}.

f : (X, $\tau$) → (Y, $\sigma$) is defined by f(a) =b ,f(b) =a , f(c) =c . Now and {a, b} is closed in Y. Here

$f^{-1}${a,b}={a,b} is r^g closed But not (r*g*)*-closed in (X, $\tau$). Hence f is not (r*g*)* continuous

**Theorem 3.12**

Every (r*g*)*-continuous map is rgb-continuous

**Proof** : Follows from proposition 3.23 [11].

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

**Example: 3.13**

Let X =Y={a,b,c} , $\tau$ = { $\phi$,X,{a},{b}, {a,b}}, (r*g*)* closed sets are φ,X,{c},{b,c},{a,c} $\sigma$ ={ $\phi$ , Y,{a,c}}. σ closed sets are $\phi$ , Y,{b}. Let f : (X, $\tau$) → (Y, $\sigma$) is defined by f(a) =c ,f(b) =b , f(c) =a . Now is,{b} is closed in Y. Here $f^{-1}${b}={b} is rgb closed But not (r*g*)*-closed in (X, $\tau$).Hence f is not (r*g*)* continuous.

**Theorem 3.14:**

Every g*-continuous map is (r*g*)*-continuous

**Proof** : Follows from proposition 3.5 [11].

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

**Example:3.15** Let X =Y={a,b,c}, $\tau$={$\phi$,X,{a}},(r*g*)* closed sets are { $\phi$,X,{b},{c} ,{a,b},{b,c},{a,c}}.g*closed sets are $\phi$,X,{b,c}. $\sigma$ ={ $\phi$ , Y,{b}}. σ closed sets are $\phi$ , Y,{a,c}. Let f : (X, $\tau$) → (Y, $\sigma$) is defined by f(a) =c ,f(b) =b , f(c) =a. Now $f^{-1}${a,c}={a,c}Which is (r*g*)* closed but not g* closed. Hence f is (r*g*)*continuous but not g*c.ntinuous.

**Theorem :3.16**

Every g**-continuous map is (r*g*)*-continuous.

**Proof** : Follows from proposition 3.13 [11].

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

**Example:3.17**

Let X =Y={a,b,c}, $\tau$ = { $\phi$,X,{a},{a,c}}, (r*g*)* closed sets = {$\phi$,X,{b} {a,b},{b,c}}, (r*g*)*closed sets {$\phi$,X,{a},{b}, {a,b},{b,c},{a,c}}. $\sigma$ ={ $\phi$ , Y,{b}}. σ closed sets are $\phi$ , Y,{a,c}, f : (X, $\tau$) → (Y, $\sigma$) is defined by f(a) =c,f(b) =b , f(c) =a. Now and {a,c} is closed in Y. Here $f^{-1}${a,c}={a,c} is (r*g*)* closed But not g**-closed in (X, $\tau$).Hence f is (r*g*)*-continuous but not g** continuous.

**Theorem 3.18**

Every g#-continuous map is (r*g*)* continuous.

**Proof** : Follows from proposition 3.15 [11].

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

**Example 3.19**

Let X =Y={a,b,c}, $\tau$ = {$\phi$,X,{a}},(r*g*)* closed sets are {$\phi$,X,{b},{c} ,{a,b},{b,c},{a,c}} $\alpha$ - closed sets { $\phi$,X,{b,c} ,{c},{b}} $\alpha$ g- closed sets { $\phi$,X,{b} ,{c},{ab},{bc},{ac}}, $\alpha$ g- open sets { $\phi$,X,{a,c},{a,b} ,{c},{a},{b}}, $\sigma$ ={ $\phi$ , Y,{a},{b},{a,b}}, σ closed sets are $\phi$ , Y,{b,c},{a,c},{c} g : (X, $\tau$) → (Y, $\sigma$) is defined by g(a)=b, g(b)=c,g(c)=a.

$g^{-1}${b,**c**}={**a**,b} is (r*g*)* closed**.** $g^{-1}${a**,**c}={**c**,b} is (r*g*)* closed**.** $g^{-1}${c}={b} is **(** r*g*)* closed g is **(**r*g*)* continuous. Now $g^{-1}${b,c}={a,b}**,** Which is not g# closed. Hence g is not g# continuous.

**Theorem: 3.20**

Every (gsp)*-continuous map is (r*g*)*-continuous.

**Proof** : Follows from proposition 3.17 [11].

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

**Example: 3.21**

Let X={a,b,c} $\tau$ = { $\phi$,X,{a}},(r*g*)* closed sets are { $\phi$,X,{b},{c} ,{a,b},{b,c},{a,c}}.gsp open sets are { $\phi$,X,{a},{b} {c} ,{a,b},{a,c}}
Let Y={a,b,c} σ={ $\phi$,Y,{b}} σ closed sets are $\phi$ , Y,{a,c}

Let f : (X, $\tau$) → (Y, $\sigma$) be defined by f(a)=b,f(c)=a f(a)=c.Now {a,c} is closed in Y. But $f^{-1}${a,c}={a,c}is (r*g*)*closed but not (gsp)*closed .Hence f is (r*g*)*continuous but not (gsp)*continuous

**Theorem 3.22**

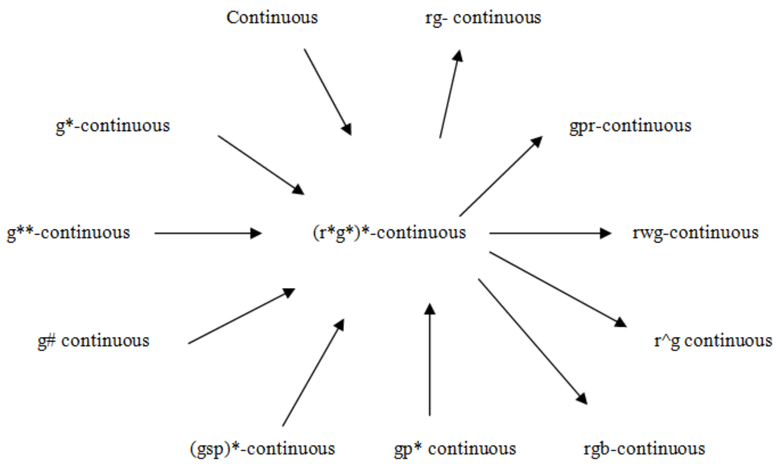
Every (gp)*-continuous map is (r*g*)*-continuous.

**Proof** : Follows proposition from 3.19 [11].

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

**Example 3.23:**

Let X={a,b,c} $\tau$ = { $\phi$,X,{c}{b,c}},
Let Y={a,b,c} σ={ $\phi$,Y,{c}} σ closed sets are $\phi$ , Y,{a,b}
Let f : (X, $\tau$) → (Y, $\sigma$) be defined by f(a)=a ,f(b)=c f(c)=b. Now {a,b} is closed in Y.But $f^{-1}${a,b}={a,c}is (r*g*)*closed but not (gp)*closed .Hence f is (r*g*)*continuous but not (gp)*continuous.
Thus we have the following Diagram.




where A ⟶ B represents A implies B and B need not imply A.

**Note :** (r*g*)*continuous is independent of pre continuous ,semi continuous , semipre continuous, wg continuous, α continuous, sg continuous, and gs continuous [11].

**Proposition: 3.24**

Composition of two (r*g*)* continuous functions need not be (r*g*)*continuous. The following example supports the above proposition.

**Example 3.25**: Let X={a,b,c}$\tau$ ={$\phi$,X,{a},{b},{a,b}}, (r*g*)* closed sets are {$\phi$,X,{c}, {b,c},{a,c}}Y={a,b,c}, σ ={$\phi$, Y, {a}}, (r*g*)* closed sets are { $\phi$,Y,{b},{c} ,{a,b},{b,c},{a,c}}. Z={a,b,c} η={φ,Z,{a,c}}

Let f : (X, $\tau$) → (Y, $\sigma$) is defined by f(a) =b ,f(b) =a , f(c) =c. Define g : (Y, $\sigma$) → (Z,$\eta$ ) by g(a)=c g(b)=b g(c)=a. Here $f^{-1}${b,c}={a,c} which is (r*g*)* closed and g-1{b}={b} which is (r*g*)* closed and hence they are( r*g*)* continuous. But $(gof)^{-1}${b}=$f^{-1}${$g^{-1}${b}}=$f^{-1}${b}={a} which is not (r*g*)* closed.

Hence (gof) is not (r*g*)*continuous.

**Definition 3.26**

A map f : (X, $\tau$) → (Y, $\sigma$) is said to be a (r*g*)*-irresolute map if $f^{-1}(V)$ is a (r*g*)*-closed set in (X, $\tau$) for every (r*g*)*-closed set V of (Y, $\sigma$) .

**Example 3.27**

Let X={a,b,c} , $\tau$ = { $\phi$,X, {a}} Closed set = { $\phi$,X, {b,c}}

(r*g*)* closed set are { $\phi$,X,{b},{a,b} {c},{b,c},{a,c} }
σ = { $\phi$,Y, {a},{b},{a,b}} Closed set of Y = { $\phi$,Y, {b,c},{a,c},{c}}
(r*g*)* closed set of Y are { $\phi$,Y, {c},{b,c},{a,c} }

Here Let f : (X, $\tau$) → (Y, $\sigma$) be defined by f(c)=c, f(b)=a, f(a)=b $f^{1}$({c})={c} , $f^{1}$({b,c})={a,c} , $f^{1}${a,c})={b,c} which are (r*g*)* closed in(X,τ). Hence f is an irresolute map.

**Theorem 3.28**

Every (r*g*)* irresolute map is (r*g*)*-continuous.

**Proof:** Let f : (X, $\tau$) → (Y, $\sigma$) be a (r*g*)*-irresolute map.

Let F be a closed set in (Y, $\sigma$).But every closed set is (r*g*)* closed.
Since f is irresolute map, ⇒ $f^{-1}$(F) is (r*g*)*-closed set in (X, $\tau$)

⇒ f is (r*g*)*-continuous

Therefore , Every (r*g*)*-irresolute map is (r*g*)*-continuous map. The converse need not be true as seen from the following example.

**Example 3.29**

Let X=Y={a,b,c}, $\tau$ = { $\phi$,X, {a},{a,c}}, Closed set = { $\phi$,X, {b,c},{b}} (r*g*)* closed set are of X are{ $\phi$,X, {a}{b}{a,b},{b,c},{a,c} }σ = { $\phi$,Y, {a}} Closed set = { $\phi$,Y, {b,c}} (r*g*)* closed sets of Y are { $\phi$,Y,{b},{a,b} {c},{b,c},{a,c} } Define a mapping f: (X, $\tau$) → (Y, $\sigma$) by f(a)=a , f (b)=c, f (c) =b .Here $f^{1}${b,c}={c,b} is (r*g*)*closed. Therefore f is (r*g*)*continuous. But $f^{1}$(b)={c}is not (r*g*)*closed in (X,τ).Therefore f is not (r*g*)*irresolute.

**Remark 3.30**

Every (r*g*)*-irresolute map is rg-continuous, gpr-continuous, rwg-continuous , rgb-continuous , r^g-continuous.

**Theorem 3.31**

Let f : (X, $\tau$) → (Y, $\sigma$) and g : (Y, $\sigma$) → (Z, $\eta$) be two function. Then

i. gof is (r*g*)*-continuous if g is continuous and f is (r*g*)*-continuous.
ii. gof is (r*g*)*-irresolute if both f and g are (r*g*)*-irresolute.
iii. gof is (r*g*)*-continuous if g is (r*g*)*-continuous and f is (r*g*)*-irresolute.

**Proof:**

i. Let f : (X, $\tau$) → (Y, $\sigma$) be (r*g*)*-continuous and g : (Y, $\sigma$) →(Z, $\eta$) be continuous. Let F be a closed set in (Z, $\eta$). Since g is continuous, $g^{-1}$(F) is closed in (Y, $\sigma$). Since f is continuous, $f^{-1}$( $g^{-1}$(F)) is (r*g*)*-closed in (X, $\tau$) Which ⇒ (gof)$^{-1}$(F) is (r*g*)*-closed. Therefore gof is (r*g*)*-continuous.
ii. Let f : (X, $\tau$) → (Y, $\sigma$) be (r*g*)*-irresolute map and let g : (Y, $\sigma$) → (Z, $\eta$) be a (r*g*)*-irresolute map .
Let F be a (r*g*)*-closed set in (Z, $\eta$), Since g is (r*g*)*-irresolute map, $g^{-1}$(F) is (r*g*)*- closed in (Y, $\sigma$) , Since f is (r*g*)*-irresolute map , $f^{-1}$( $g^{-1}$(F)) is (r*g*)*-closed in (X, $\tau$) Which ⇒ (gof)$^{-1}$(F) is (r*g*)*-closed (X, $\tau$). ⇒ gof is (r*g*)*-irresolute map.
iii. Let f : (X, $\tau$) → (Y, $\sigma$) be (r*g*)*-irresolute and g : (Y, $\sigma$) →(Z, $\eta$) be (r*g*)*-continuous.
Let F be a closed set in (Z, $\eta$). Since g is (r*g*)*-continuous, $g^{-1}$(F) is (r*g*)*-closed in (Y, $\sigma$). Since f is (r*g*)*-irresolute, $f^{-1}$( $g^{-1}$(F)) is (r*g*)*-closed in (X, $\tau$).

⇒ (gof)$^{-1}$(F) is (r*g*)*-closed.Which ⇒ (gof ) is (r*g*)*-continuous

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