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ON CONTRA-GENERALIZED C*-IRRESOLUTE FUNCTIONS IN TOPOLOGICAL SPACES

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Abstract: The aim of this paper is to introduce the notion of contra-generalized c*-irresolute functions in topological spaces and study their basic properties. Also, we see that composition of two contra-generalized c*-irresolute functions is contra-generalized c*-irresolute function. This is the main part of this paper. Also, the contra-generalized c*-irresolute function of a generalized c*-irresolute function is contra-generalized c*-irresolute function. Further, we prove contra-generalized c*-irresolute function is the stronger form of contra-gc*-continuous function.

Key words: gc*-continuous functions,contra-gc*-continuous functions, gc*-irresolute functions and contra-gc*-irresolute functions.

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1. Introduction

In 1963, Norman Levine [5] introduced semi-open sets in topological spaces. Also in 1970, he introduced the concept of generalized closed sets.In 1980, Jain[4] introduced totally continuous functions. Dontchev[3] introduced the notions of contra continuity in topological spaces in 1996. In 2011,S.S. Benchalli and Umadevi I Neeli[1]introduced the concept of semi-totally continuous functions in topological spaces.In this paper we introduce contra-generalized c*-irresolute functions in topological spaces and study their basic properties.Section 2 deals with the preliminary concepts. In section 3, contra-generalized c*-irresolute functions are introduced and study their basic properties.

2. Preliminaries

Throughout this paper X denotes a topological space on which no separation axiom is assumed. For any subset A of X, cl(A) denotes the closure of A, int(A) denotes the interior of A. Further X\A denotes the complement of A in X. The following definitions are very useful in the subsequent sections.

Definition: 2.1 [5]A subset A of a topological space X is said to be a semi-open set if A⊆cl(int(A)) and a semi-closed set if int(cl(A))⊆A.

Definition: 2.2 [14]A subset A of a topological space X is said to be a α-open set if A⊆int(cl(int(A))) and a α-closed set if cl(int(cl(A)))⊆A.

Definition: 2.3 [6]A subset A of a topological space X is said to be a c*-open set if int(cl(A))⊆A⊆cl(int(A)).

Definition: 2.4 [6]A subset A of a topological space X is said to be a generalized c*-closed set (briefly, gc*-closed set)if cl(A)⊆H whenever A⊆H andH is c*-open. The complement of the gc*-closed set is gc*-open [7].

Definition: 2.5 [9]A subset A of a topological space X is said to be apre-generalized c*-closed set (briefly, pgc*-closed set)if pcl(A)⊆H whenever A⊆H andH is c*-open. The complement of thepgc*-closed set is pgc*-open [10].

Definition: 2.6A function f : X → Y is called

i. totally-continuous [4] if the inverse image of every open subset of Y is clopen in X,
ii. strongly-continuous [15] if the inverse image of every subset of Y is clopen subset of X,
iii. semi-totally continuous [1] if the inverse image of every semi-open subset of Y is clopen in X &

iv. contra-continuous [3] if the inverse image of every open subset of Y is closedin X.

Definition: 2.7 [8]A function f : X → Y is called a generalized c*-continuous (briefly, gc*-continuous) function if the inverse image of every closed subset of Y is gc*-closed in X.

Definition: 2.8 [11]A function f : X → Y is called a pre-generalized c*-continuous (briefly, pgc*-continuous) function if the inverse image of every closed subset of Y is pgc*-closed in X.

Definition: 2.9 [12]Let X and Y be two topological spaces. A function f : X → Y is called a contra-generalized c*-continuous (briefly, contra-gc*-continuous) functionif $f^{-1}(V)$ is gc*-closed in X for every open set V of Y .

Definition: 2.10[13]Let X and Y be two topological spaces. A function f : X → Y is called a contra-pre-generalized c*-continuous (briefly, contra-pgc*-continuous) functionif $f^{-1}(V)$ is pgc*-closed in X for every open set V of Y .

Definition: 2.11[2]A function f : X → Y is called an irresolute function if the inverse image of every semi-open subset of Y is semi-open in X.

Definition: 2.12[8]A function f : X → Y is called a generalized c*-irresolute (briefly, gc*-irresolute) function if the inverse image of every gc*-closed subset of Y is gc*-closed in X.

Definition: 2.13[11]A function f : X → Y is called a pre-generalized c*-irresolute (briefly, pgc*-irresolute) function if the inverse image of every pgc*-closed subset of Y is pgc*-closed in X.

3. Contra-generalized c*-irresolute functions

In this section, we introduce contra-generalized c*-irresolute functions and study their basic properties. Now, we begin with the definition of contra-generalized c*-irresolute function.

Definition: 3.1 Let X and Y be two topological spaces. A function f : X → Y is said to be a contra-generalized c*-irresolute (briefly, contra-gc*-irresolute) function if $f^{-1}(V)$is gc*-closedin X for every gc*-open set V of Y.

Example: 3.2 Let X={1,2,3,4} and Y={a,b,c,d}. Then, clearly τ={ϕ,{1},{2,3,4},X} is a topology on X and σ={ϕ,{a},{b},{a,b},{b,c},{a,b,c},{a,b,d},Y} is a topology on Y. Define f by f(1)=b, f(2)=d, f(3)=c, f(4)=a. Then the inverse image of every gc*-open set in Y is gc*-closed in X. Therefore, f is contra-gc*-irresolute.

Proposition: 3.3 Let X,Y be two topological spaces. Then f:X→Y is contra-gc*-irresolute iff $f^{-1}(U)$ is gc*-open in X for every gc*-closed set U of Y.

Proof: Assume that f : X → Y is contra-gc*-irresolute. Let U be a gc*-closed set in Y. Then Y\U is a gc*-open set in Y. This implies, $f^{-1}(Y\setminus U)$ is a gc*-closed set in X. Since $f^{-1}(Y\setminus U)=X\setminus f^{-1}(U)$, we have $X\setminus f^{-1}(U)$ is a gc*-closed set in X. This implies, $f^{-1}(U)$ is a gc*-open set in X. Conversely, assume that $f^{-1}(U)$ is gc*-open in X for every gc*-closed set U in Y. Let V be a gc*- open set in Y. Then Y\V is gc*-closed in Y. Therefore, $f^{-1}(Y\setminus V)$ is gc*-open in X. That is, $X\setminus f^{-1}(V)$ is gc*-open in X. This implies, $f^{-1}(V)$ is gc*-closed in X. Therefore, f is contra-gc*-irresolute.

Proposition: 3.4 Let X,Y be two topological spaces. Then every contra-gc*-irresolute function is contra-gc*-continuous.

Proof: The proof follows easily from the fact that every closed set is gc*-closed.

The following example shows that the converse of Proposition 3.4 need not be true.

Example:3.5 Let X={a,b,c,d} with topology τ={ϕ,{a},{b},{a,b},{b,c},{a,b,c},{a,b,d},X} and Y={1,2,3,4} with topology σ={ϕ,{1},{3},{1,3},{2,3,4},Y}. Define f:X→Y by f(a)=4, f(b)=2, f(c)=1, f(d)=3. Then the inverse image of every open set in Y is gc*-closed in X. Therefore, f is contra-gc*-continuous. But f is not a contra-gc*-irresolute, since the inverse image of the gc*-open set {2} is {b}, which is not a gc*-closed set in X.

Proposition: 3.6 Let X,Y be two topological spaces. Then every contra-gc*-irresolute function is contra-pgc*-continuous.

Proof: Let f : X → Y be a contra-gc*-irresolute function. Let V be a closed set in Y. Then V is gc*-closed in Y. By our assumption, $f^{-1}(V)$ is gc*-open in X. This implies, $f^{-1}(V)$ is pgc*-open in X. Therefore, f is contra-pgc*-continuous.

The converse of Proposition 3.6 need not be true as seen from the following example.

Example: 3.7 Let X={a,b,c,d} with topology τ={ϕ,{a},{b},{a,b},{a,c},{a,b,c},X} and Y={1,2,3,4,5} with topology σ={ϕ,{1,2},{3,4},{1,2,3,4},Y}. Define f:X→Y by f(a)=2, f(b)=1, f(c)=4, f(d)=3. Then the inverse image of every open set in Y is pgc*-closed in X. Therefore, f is contra-pgc*-continuous. But f is not a contra-gc*-irresolute, since the inverse image of the gc*-open set {1} in Y is {b}, which is not a gc*-closed set in X.

Proposition: 3.8 Let X,Y and Z be topological spaces. Then

1. If f : X → Y is contra-gc*-irresolute and g : Y → Z is continuous (resp. gc*-continuous), then g∘f : X → Z is contra-gc*-continuous,
2. If f : X → Y is contra-gc*-irresolute and g: Y → Z is gc*-irresolute, then g∘f: X → Z is contra-gc*-irresolute,
3. If f : X → Y is contra-gc*-irresolute and g: Y → Z is gc*-irresolute, then g∘f: X → Z is contra-gc*-continuous &
4. If f : X → Y is gc*-irresolute and g: Y → Z is contra-gc*-irresolute, then g∘f: X → Z is contra-gc*-irresolute.

Proof: It is obvious.

The following Proposition shows that the composition of contra-gc*-irresolute function and some functions is contra-pgc*-continuous function.

Proposition: 3.9 Let X,Y and Z be topological spaces.Then

1. If f : X → Y is contra-gc*-irresolute and g : Y → Z is continuous, then g∘f : X → Z is contra-pgc*-continuous,
2. If f : X → Y is contra-gc*-irresolute and g: Y → Z is gc*-continuous, then g∘f: X → Z is contra-pgc*-continuous,
3. If f : X → Y is pgc*-irresolute and g: Y → Z is contra-gc*-irresolute, then g∘f: X → Z is contra-pgc*-continuous.

Proposition: 3.10 Let X,Y and Z be topological spaces.

1. If f : X → Y is contra-gc*-irresolute and g : Y → Z is contra-continuous (resp. contra-gc*-continuous), then g∘f : X → Z is gc*-continuous,
2. If f : X → Y is contra-gc*-irresolute and g : Y → Z is contra-gc*-continuous, then g∘f : X → Z is gc*-continuous (resp. pgc*-continuous),
3. If f : X → Y and g: Y → Z arecontra-gc*-irresolute, then g∘f: X → Z is gc*-continuous (resp. pgc*-continuous) &
4. If f : X → Y and g: Y → Z arecontra-gc*-irresolute, then g∘f: X → Z is gc*-irresolute.

Proof: The proof is trivial.

Proposition: 3.11 Let X,Y and Z be topological spaces. Then

1. If f : X → Y is contra-gc*-irresolute and g : Y → Z is totally-continuous, then g∘f : X → Z is gc*-continuous (resp. pgc*-continuous),
2. If f : X → Y is contra-gc*-irresolute and g: Y → Z is strongly-continuous, then g∘f: X → Z is gc*-continuous (resp. pgc*-continuous),
3. If f : X → Y is contra-gc*-irresolute and g: Y → Z is semi-totally continuous, then g∘f: X → Z is gc*-continuous (resp. pgc*-continuous).

Proposition: 3.12 Let X,Y and Z be topological spaces.Then

1. If f : X → Y is contra-gc*-irresolute and g : Y → Z is totally-continuous, then g∘f : X → Z is contra-gc*-continuous,

2. If f : X → Y is contra-gc*-irresolute and g: Y → Z is strongly-continuous, then g∘f: X → Z is contra-gc*-continuous,
3. If f : X → Y is contra-gc*-irresolute and g: Y → Z is semi-totally continuous, then g∘f: X → Z is contra-gc*-continuous.

In other words, totally-continuous (resp. strongly-continuous, semi-totally continuous) function of a contra-gc*-irresolute function is contra-gc*-continuous.

Proposition: 3.13 Let X,Y and Z be topological spaces.Then

1. If f : X → Y is contra-gc*-irresolute and g : Y → Z is totally-continuous, then g∘f : X → Z is contra-pgc*-continuous,
2. If f : X → Y is contra-gc*-irresolute and g: Y → Z is strongly-continuous, then g∘f: X → Z is contra-pgc*-continuous&
3. If f : X → Y is contra-gc*-irresolute and g: Y → Z is semi-totally continuous, then g∘f: X → Z is contra-pgc*-continuous.

Proof: The proof follows from the fact that every gc*-closed set is pgc*-closed.

Irresolute and contra-gc*-irresolute functions are independent of each other. For example, let X={1,2,3,4} and Y={a,b,c,d}. Then, clearly τ={ϕ,{1},{3},{4},{1,3},{1,4},{3,4},{1,3,4},X} is a topology on X and σ={ϕ,{a},{b},{a,b},{b,c},{a,b,c},{a,b,d},Y} is a topology on Y. Define f:X→Y by f(1)=b, f(2)=d, f(3)=c, f(4)=a. Then f is irresolute. But f is not contra-gc*-irresolute, since the inverse image of the gc*-open set {a,c} is {3,4}, which is not a gc*-closed set in X. Define g:X→Y by g(1)=g(3)=g(4)=a, g(2)=b. Then g is contra-gc*-irresolute. But the inverse image of the semi-open set {b,c,d} is {2}, which is not a semi-open set in X. Therefore, g is not irresolute.

Proposition: 3.14 Let X,Y and Z be topological spaces.If f : X → Y and g: Y → Z arecontra-gc*-irresolute, then g∘f: X → Z is contra-gc*-irresolute.

Proof: Let X={$x_1,x_2,\ldots,x_n$}, Y={$y_1,y_2,\ldots,y_m$}and Z={$z_1,z_2,\ldots,z_p$} with n<m<p. Then there are four cases arise.

Case (i) : Suppose f and g are 1-1. Define f&g by $f(x_i)=y_i$ for all i=1,2,…,n and $g(y_j)=z_j$ for all j=1,2,…m. Since each {y_i} is gc*-open and f is contra-gc*-irresolute, we have {$f^{-1}(y_i)$}={x_i} is gc*-closed. That is, each {x_i} is gc*-closed in X. Since union of gc*-closed sets is gc*-closed, we have every subset of X is gc*-closed in X. This implies, inverse image of every gc*-open set in Z under g∘f is gc*-closed in X. Therefore, g∘f is contra-gc*-irresolute.

Case (ii) : Suppose f is 1-1 and g is not 1-1. Define f by $f(x_1)=y_1$, $f(x_2)=y_2$,…, $f(x_n)=y_n$ and define gby $g(y_1)=g(y_2)=\ldots=g(y_k)=z_k$, $g(y_{k+1})=z_{k+1},\ldots,g(y_m)=z_m$, where 1<k<m. Since every singleton sets are gc*-open, we have {z_k}, {z_{k+1}},…, {z_m} are gc*-open in Z & {y_1},{y_2},…, {y_n}are gc*-open in Y. Also, since f and g are contra-gc*-irresolute, we have $g^{-1}(\{z_k\})$, $g^{-1}(\{z_{k+1}\})$,…, $g^{-1}(\{z_n\})$ are gc*-closed in Y and $f^{-1}(\{y_1\})$, $f^{-1}(\{y_2\})$,…, $f^{-1}(\{y_n\})$ are gc*-closed in X. That is, {$y_1,y_2,\ldots,y_k$}, {y_{k+1}},…,{y_m} are gc*-closed in Y and {x_1}, {x_2},…, {x_n} are gc*-closed in X. Since union of gc*-closed sets in X is gc*-closed in X, we have every subset of X is gc*-closed in X. This implies, inverse image of every gc*-open set in Z under g∘f is gc*-closed in X. Therefore, g∘f is contra-gc*-irresolute.

Case (iii) : Suppose g is 1-1 and f is not 1-1. Define f by $f(x_1)=f(x_2)=\ldots=f(x_k)=y_k$, $f(x_{k+1})=y_{k+1},\ldots$, $f(x_n)=y_n$, where1<k<n and define g by $g(y_1)=z_1$, $g(y_2)=z_2,\ldots$, $g(y_m)=z_m$. Since each {z_i} and each {y_i} are gc*-open in Z and Y respectively and f&g are contra-gc*-irresolute, we have each {y_i} is gc*-closed in Y and {$x_1,x_2,\ldots,x_k$}, {x_{k+1}},…, {x_n} are gc*-closed in X. Now,

$(g\circ f)^{-1}(\{z_1\})=f^{-1}(g^{-1}(\{z_1\}))=f^{-1}(\{y_1\})=\phi$,

$(g\circ f)^{-1}(\{z_2\})=f^{-1}(g^{-1}(\{z_2\}))=f^{-1}(\{y_2\})=\phi$,

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$(g\circ f)^{-1}(\{z_{k-1}\})=f^{-1}(g^{-1}(\{z_{k-1}\}))=f^{-1}(\{y_{k-1}\})=\phi$,
$(g\circ f)^{-1}(\{z_k\})=f^{-1}(g^{-1}(\{z_k\}))=f^{-1}(\{y_k\})=\{x_1,x_2,\ldots x_k\}$,
$(g\circ f)^{-1}(\{z_{k+1}\})=f^{-1}(g^{-1}(\{z_{k+1}\}))=f^{-1}(\{y_{k+1}\})=\{x_{k+1}\}$,
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$(g\circ f)^{-1}(\{z_n\})=f^{-1}(g^{-1}(\{z_n\}))=f^{-1}(\{y_n\})=\{x_n\}$,
$(g\circ f)^{-1}(\{z_{n+1}\})=f^{-1}(g^{-1}(\{z_{n+1}\}))=f^{-1}(\{y_{n+1}\})=\phi$,
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$(g\circ f)^{-1}(\{z_m\})=f^{-1}(g^{-1}(\{z_m\}))=f^{-1}(\{y_m\})=\phi$,
$(g\circ f)^{-1}(\{z_{m+1}\})=f^{-1}(g^{-1}(\{z_{m+1}\}))=f^{-1}(\{\phi\})=\phi$,
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$(g\circ f)^{-1}(\{z_p\})=f^{-1}(g^{-1}(\{z_p\}))=f^{-1}(\{\phi\})=\phi$,which are gc*-closed in X.
That is, each $(g\circ f)^{-1}(\{z_i\})$ is gc*-closed in X.
If $\{z_1,z_2,\ldots,z_s\}$, $1<s<p$ is gc*-open in Z, then $(g\circ f)^{-1}(\{z_1,z_2,\ldots,z_s\})=(g\circ f)^{-1}(\{z_1\})\cup(g\circ f)^{-1}(\{z_2\})\cup\ldots\cup(g\circ f)^{-1}(\{z_s\})$.
Since the union of gc*-closed sets in gc*-closed, we have $(g\circ f)^{-1}(\{z_1,z_2,\ldots,z_s\})$ is gc*-closed.Therefore, inverse image of every gc*-open set in Z under $g\circ f$ is gc*-closed in X. Hence $g\circ f$ is contra-gc*-irresolute.

Case (iv) : Suppose f and g are not 1-1. Define f by $f(x_1)=f(x_2)=\ldots=f(x_k)=y_k$, $f(x_{k+1})=y_{k+1},\ldots, f(x_n)=y_n$, where $1<k<n$. Define g by $g(y_1)=g(y_2)=\ldots=g(y_r)=z_r$, $g(y_{r+1})=z_{r+1},\ldots,g(y_m)=z_m$, where $1<r<m$. Since each $\{z_i\}$ and each $\{y_i\}$ are gc*-open in Z and Y respectively and f,g are contra-gc*-irresolute, we have $\{x_1,x_2,\ldots,x_k\},\{x_{k+1}\},\ldots,\{x_n\}$ are gc*-closed in X and $\{y_1,y_2,\ldots,y_r\}$, $\{y_{r+1}\},\ldots, \{y_m\}$ are gc*-closed in Y. Now,
$(g\circ f)^{-1}(\{z_1\})=f^{-1}(g^{-1}(\{z_1\}))=f^{-1}(\{\phi\})=\phi$,
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$(g\circ f)^{-1}(\{z_{r-1}\})=f^{-1}(g^{-1}(\{z_{r-1}\}))=f^{-1}(\{\phi\})=\phi$,
$(g\circ f)^{-1}(\{z_r\})=f^{-1}(g^{-1}(\{z_r\}))=f^{-1}(\{y_1,y_2,\ldots y_r\})$
$=f^{-1}(\{y_1\})\cup f^{-1}(\{y_2\})\cup\ldots\cup f^{-1}(\{y_r\})$
$=\phi\cup\phi\cup\ldots\cup f^{-1}(\{y_r\})$
$=f^{-1}(\{y_r\})$
$=\begin{cases}\phi & if\ r<k\\ \{x_1,x_2,\ldots,x_k\}\cup\{x_{k+1}\}\cup\ldots\cup\{x_r\}\cup\{x_{r+1}\} & if\ r\geq k\end{cases}$
$=\begin{cases}\phi & if\ r<k\\ \{x_1,x_2,\ldots,x_{r+1}\} & if\ r\geq k\end{cases}$
$(g\circ f)^{-1}(\{z_{r+1}\})=f^{-1}(g^{-1}(\{z_{r+1}\}))=f^{-1}(\{y_{r+1}\})$
$=\begin{cases}\phi & if\ r+1<k\\ \{x_1,x_2,\ldots,x_k\}\cup\{x_{k+1}\}\cup\ldots\cup\{x_r\}\cup\{x_{r+1}\} & if\ r+1\geq k\end{cases}$
$=\begin{cases}\phi & if\ r<k-1\\ \{x_1,x_2,\ldots,x_{r+1}\} & if\ r\geq k-1\end{cases}$,
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$(g\circ f)^{-1}(\{z_n\})=f^{-1}(g^{-1}(\{z_n\}))=f^{-1}(\{y_n\})=\{x_n\}$,
$(g\circ f)^{-1}(\{z_{n+1}\})=f^{-1}(g^{-1}(\{z_{n+1}\}))=f^{-1}(\{y_{n+1}\})=\phi$,
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$(g\circ f)^{-1}(\{z_m\})=f^{-1}(g^{-1}(\{z_m\}))=f^{-1}(\{y_m\})=\phi$,
$(g\circ f)^{-1}(\{z_{m+1}\})=f^{-1}(g^{-1}(\{z_{m+1}\}))=f^{-1}(\{\phi\})=\phi$,
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$(g\circ f)^{-1}(\{z_p\})=f^{-1}(g^{-1}(\{z_p\}))=f^{-1}(\{\phi\})=\phi$,which are gc*-closed in X.
That is, each $(g\circ f)^{-1}(\{z_i\})$ is gc*-closed in X.
If $\{z_1,z_2,\ldots,z_q\}$, $1<q<p$ is gc*-open in Z, then $(g\circ f)^{-1}(\{z_1,z_2,\ldots,z_q\})=(g\circ f)^{-1}(\{z_1\})\cup(g\circ f)^{-1}(\{z_2\})\cup\ldots\cup(g\circ f)^{-1}(\{z_q\})$.

Since the union of gc*-closed sets in gc*-closed, we have $(g\circ f)^{-1}(\{z_1,z_2,\ldots,z_s\})$ is gc*-closed. Therefore, inverse image of every gc*-open set in Z under g∘f is gc*-closed in X. Hence g∘f is contra-gc*-irresolute.

Conclusion: In this paper we have introduced contra-gc*-irresolute functions in topological spaces. Also, we have studied the relationship between contra-gc*-irresolute functions and other continuous and irresolute functions already exist.

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