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A New Generalized Function in Ideal Topological Spaces

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Abstract

This paper propose a weak form of generalized continuous function in ideal topological space and also a particular type of generalized closedset is introduced. Using this set, some properties of generalized continuousfunctions are investigated.

Key words: $I_{\tilde{\tilde{g}}s}$-closed sets, maximal $I_{\tilde{\tilde{g}}s}$-closed sets, $I_{\tilde{\tilde{g}}s}$-continuous functions, maximal $I_{\tilde{\tilde{g}}s}$-continuous functions.

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1. Introduction

Ideals in topological spaces has been considered since 1930. In 1990, Jankovic and Hamlett[3] once again investigated the properties of idealtopological spaces. Also Khan and Noiri[5] introduced and studied theproperties of sgI-closed sets in ideal topological spaces. Navaneethakrishnan andJoseph[9] further investigated and characterized I_g-closed sets bythe use of local functions. Weak form of open sets called semi-open setsand also the first step of generalizing closed sets was done by Levine[7,8]. Recently, Jayaparthasarathy[4] introduced a new class of generalized closedsets called $I_{\tilde{\tilde{g}}s}$-closed sets in ideal topological spaces and investigate its properties. This paper expresses a weak form of generalized continuous function inideal topological space called $I_{\tilde{\tilde{g}}s}$-continuous function and also it investigatedsome properties of a particular type of generalized closed set called maximal $I_{\tilde{\tilde{g}}s}$-closed set.

2. Preliminaries :

In this section we discuss some basic properties about ideal topologicalspaces and weak form of open sets in topological spaces which are useful insequel.

Definition 2.1[3] An ideal I on a topological space (X, τ) is a non-empty collection of subsets of X satisfying the following two conditions:

(i) If A∈I and B⊂A, then B∈I
(ii) If A∈I and B∈I, then A∪B∈I.

Let (X, τ) be a topological space and I an ideal of subsets of X. An ideal topological space is a topological space (X, τ) with an ideal I on X and is denoted by (X, τ, I).

Definition 2.2[1,3] For a subset A of X, A_s^*(I, τ) ={x ∈ X: U∩A ∉ I for every U∈SO(X, x)} is called the semi-local function of A with respect to ideal I and topology τ, where SO(X, x)={U∈SO(X) : x ∈ U}. Also we define Cl_s^* by Cl_s^*(A) =A∪A_s^* and there exists a topology τ_s^*(I) finer than τ and τ*, defined by τ_s^*(I)={U⊆X: Cl_s^*(X–U) =X–U} which is generated by the base β_s(I, τ) ={U–J: U∈τ and J∈I}. Note that A_s^*=sCl(A_s^*)⊆ A* ⊆ Cl_s^*(A) and Int_s^*(A) denote the interior of the set A in (X, τ_s^*, I).

Definition 2.3[4] A subset A of an ideal topological space (X, τ, I) is said to be $I_{\tilde{\tilde{g}}s}$-closed if $A_s^* \subseteq U$ whenever $A \subseteq U$ and U is $\tilde{g}s$-open in X. The complement of $I_{\tilde{\tilde{g}}s}$-closed set is called $I_{\tilde{\tilde{g}}s}$-open set.

Theorem 2.4[4] Let (X, τ, I) be an ideal topological space. Then the following are true.

(i) Every I_g-closed set is $I_{\tilde{\tilde{g}}s}$-closed, but not converse.
(ii) Every $I_{\hat{g}}$-closed set is $I_{\tilde{\tilde{g}}s}$-closed, but not converse.
(iii) Every ∗-closed set is $I_{\tilde{\tilde{g}}s}$-closed, but not converse.
(iv) Every semi-∗-closed set is $I_{\tilde{\tilde{g}}s}$-closed, but not converse.
(v) Every $I_{\tilde{\tilde{g}}s}$-closed is sgI, but not converse.
(vi) If $A \subseteq U$ is an element of I, then A is $I_{\tilde{\tilde{g}}s}$-closed.

Theorem 2.5[4] Let $\{A_i : i \in \Omega\}$ be a locally finite family of $I_{\tilde{\tilde{g}}s}$-closed sets of an ideal topological space (X, τ, I). Then $\bigcup_{i\in\Omega} A_i$ is $I_{\tilde{\tilde{g}}s}$-closed set.

Theorem 2.6[4] Let (X, τ, I) be an ideal topological space and $A \subseteq U$. Then A is $I_{\tilde{\tilde{g}}s}$-open if and only if $F \subseteq Int_s^*(A)$ whenever F is $\tilde{g}s$-closed and $F \subseteq A$.

Theorem 2.7[4] Let (X, τ, I) be an ideal topological space. Then every $\tilde{g}s$-closed is $I_{\tilde{\tilde{g}}s}$-closed, but not conversely.

Definition 2.8[10] For any function f: (X, τ, I)→(Y, σ), f(I) is an ideal on Y.

3. $I_{\tilde{\tilde{g}}s}$-*Continuous Functions*

This section introduces a generalized continuous function in ideal topological spaces and investigates some properties of it.

Definition 3.1 A function f: (X, τ, I)→(Y, σ) is said to be $I_{\tilde{\tilde{g}}s}$-continuous if f^{-1}(V) is $I_{\tilde{\tilde{g}}s}$-closed in X for every closed set V of Y.

Example 3.2 LetX=Y={a, b, c}, τ ={$\emptyset$,{a}, X}, σ={$\emptyset$,{b}, Y} and I={$\emptyset$, {a}, {b}, {a, b}}. Define f: (X, τ, I)→(Y, σ) by f(a) =c, f(b)=a and f(c) =b. Then f is $I_{\tilde{\tilde{g}}s}$-continuous function.

Theorem 3.3 A subset A of an ideal space (X, τ, I) is $I_{\tilde{\tilde{g}}s}$-continuous if andonly if $f^{-1}(V)$ is $I_{\tilde{\tilde{g}}s}$-open in X for every open set V of Y.

Proof. Assume f is $I_{\tilde{\tilde{g}}s}$-continuous function and V be any open set in Y. Then $f^{-1}(V^c)$ is $I_{\tilde{\tilde{g}}s}$-closed in X. Then $[f^{-1}(V)]^c$ is $I_{\tilde{\tilde{g}}s}$-closed in X and so $f^{-1}(V)$ is $I_{\tilde{\tilde{g}}s}$-open in X. Conversely, assume that $f^{-1}(V)$ is $I_{\tilde{\tilde{g}}s}$-open in X for every open set V of Y and F be a $I_{\tilde{\tilde{g}}s}$-closed set in Y. Then $f^{-1}(F^c)$ is $I_{\tilde{\tilde{g}}s}$-open in X and so $[f^{-1}(F)]^c$ is $I_{\tilde{\tilde{g}}s}$-open in X. Thus, $f^{-1}(F)$ is $I_{\tilde{\tilde{g}}s}$-closed in X and f is a $I_{\tilde{\tilde{g}}s}$-continuous function on X.

Remark 3.4 In an ideal space (X, τ, I), the composition of two $I_{\tilde{\tilde{g}}s}$-continuous functions need not be $I_{\tilde{\tilde{g}}s}$-continuous. For example, let X=Y =Z= {a,b,c,d}, τ={$\emptyset$,{a}, {b,c}, {a,b,c},X}, σ={$\emptyset$,{a},{b},{a, b}, Y}, μ={$\emptyset$,{a, c, d}, Z}, I_1={$\emptyset$,{a}} and I_2={$\emptyset$, {d}}. Let f: (X, τ, I_1)→(Y, σ) be defined by f(a) = c, f(b) = a, f(c) = b and f(d) = d and also defineg: (Y, σ, I_2)→(Z, μ) by g(a) =b, g(b) =c, g(c) =d and g(d) =a. Then both f and g are $I_{\tilde{\tilde{g}}s}$-continuous functions. But g∘f is not a $I_{\tilde{\tilde{g}}s}$-continuous function, since $(g\circ f)^{-1}(\{b\})$ = $f^{-1}(g^{-1}(\{b\})) = f^{-1}(\{c\})$ = {b} is not $I_{\tilde{\tilde{g}}s}$-closed in X whenever {b} is closed in Z.

Theorem 3.5 Letf : (X, τ, I)→(Y, σ) and g : (Y, σ)→(Z, μ), be any two functions. Then g∘f is $I_{\tilde{\tilde{g}}s}$-continuous if f is $I_{\tilde{\tilde{g}}s}$-continuous and giscontinuous.

Proof. Let F be a closed set inZ. Since gis a continuous function, $g^{-1}(F)$ is closed in Y. By $I_{\tilde{\tilde{g}}s}$-continuity of f, $f^{-1}(g^{-1}(F))$ is $I_{\tilde{\tilde{g}}s}$-closed in X and so g∘f is $I_{\tilde{\tilde{g}}s}$-continuous.

Definition 3.6 A functionf : (X, τ, I_1) → (Y, σ, I_2) is said to be $I_{\tilde{\tilde{g}}s}$-irresolute if $f^{-1}(V)$ is $I_{\tilde{\tilde{g}}s}$-closed in X for every $I_{\tilde{\tilde{g}}s}$-closed set V of Y.

Example 3.7 Let X=Y={a, b, c}, τ={$\emptyset$,{a}, X}, σ={$\emptyset$,{a},{a,b}, Y},I_1 ={$\emptyset$, {a}, {b},{a, b}} and I_2 ={$\emptyset$,{a}}. Then f: (X, τ, I_1) → (Y, σ, I_2) defined by f(a) =b, f(b) =c, and f(c) =a is $I_{\tilde{\tilde{g}}s}$-irresolute function.

Theorem 3.8 A subsetAof an ideal space (X, τ, I) is $I_{\tilde{\tilde{g}}s}$-irresolute if andonly if $f^{-1}(V)$ is $I_{\tilde{\tilde{g}}s}$-open in X for every $I_{\tilde{\tilde{g}}s}$-open set V of Y.

Proof. Assume f is $I_{\tilde{\tilde{g}}s}$-irresolute function and V be any $I_{\tilde{\tilde{g}}s}$-open set in Y. Then $f^{-1}(V^c)$ is $I_{\tilde{\tilde{g}}s}$-closed in X. Then $[f^{-1}(V)]^c$ is $I_{\tilde{\tilde{g}}s}$-closed in X and so $f^{-1}(V)$ is $I_{\tilde{\tilde{g}}s}$-open in X. Conversely, assume that $f^{-1}(V)$ is $I_{\tilde{\tilde{g}}s}$-open in X for every

$I_{\tilde{g}s}$-open set V of Y and F be a $I_{\tilde{g}s}$-closed set in Y. Then $f^{-1}(F^c)$ is $I_{\tilde{g}s}$-open in X and so $[f^{-1}(F)]^c$ is $I_{\tilde{g}s}$-open in X. Thus, $f^{-1}(F)$ is $I_{\tilde{g}s}$-closed in X and f is a $I_{\tilde{g}s}$-irresolute function on X.

Theorem 3.9 Let f: $(X, \tau, I_1)\to(Y, \sigma, I_2)$ and g: $(Y, \sigma, I_2)\to(Z, \mu, I_3)$ be any two functions. Then the following statements are true:

i) g∘f is $I_{\tilde{g}s}$-continuous if f is $I_{\tilde{g}s}$-irresolute and g is $I_{\tilde{g}s}$-continuous.

ii) g∘f is $I_{\tilde{g}s}$-irresolute if f is $I_{\tilde{g}s}$-irresolute and g is $I_{\tilde{g}s}$-irresolute.

Proof. (i): Let F be a closed set in Z. Since g is a $I_{\tilde{g}s}$-continuous function, $g^{-1}(F)$ is $I_{\tilde{g}s}$-closed in Y. Since f is $I_{\tilde{g}s}$-irresolute, $f^{-1}(g^{-1}(F))$ is $I_{\tilde{g}s}$-closedin X and so g∘f is $I_{\tilde{g}s}$-continuous.

(ii): Let F be an $I_{\tilde{g}s}$-closed set in Z. Since gis a $I_{\tilde{g}s}$-continuous function, $g^{-1}(F)$ is $I_{\tilde{g}s}$-closed in Y. Since f is $I_{\tilde{g}s}$-irresolute, $f^{-1}(g^{-1}(F))$ is $I_{\tilde{g}s}$-closedin X and so g∘f is $I_{\tilde{g}s}$-continuous.

Definition 3.10 A mapping f : $(X, \tau) \to (Y, \sigma)$ is called $\tilde{g}s^*$-closed if the image of every $\tilde{g}s$-closed set in (X, τ) is $\tilde{g}s$-closed in (Y, σ).

Example 3.11 Let X=Y={a, b, c, d}, $\tau=\{\emptyset,\{a, b\}, X\}$ and $\sigma=\{\emptyset,\{a\},\{c, d\},\{a, c, d\}, \{b, c, d\}, Y\}$. Define f : $(X, \tau)\to(Y, \sigma)$ by f(a) =c, f(b) =d, f(c) =a, f(d) =b. Then f is a $\tilde{g}s^*$-closed map.

Theorem 3.12 If f : $(X, \tau, I_1) \to(Y, \sigma)$ is $I_{\tilde{g}s}$-continuous and $\tilde{g}s^*$-closedmap, then f is $I_{\tilde{g}s}$-irresolute.

Proof. Suppose V is $I_{\tilde{g}s}$-closed in Y and $f^{-1}(V)\subseteq U$ where U is $\tilde{g}s$-open in X. Then $X–U\subseteq X–f^{-1}(V) =f^{-1}(Y–V)$ and hence $f(X–U) \subseteq Y–V$. Since f is $\tilde{g}s^*$-closed, f(X–U) is $\tilde{g}s$-closed. By theorem 2.7, $f(X–U)\subseteq int_s^*(Y–V) =Y–cl_s^*(V)$. Now $X–U \subseteq f^{-1}(f(X–U))\subseteq f^{-1}(Y–cl_s^*(V))=X–f^{-1}(cl_s^*(V))$ which implies $f^{-1}(cl_s^*(V))\subseteq U$. Since f is $I_{\tilde{g}s}$-continuous, $f^{-1}(cl_s^*(V))$ is $I_{\tilde{g}s}$-closed and so $cl_s^*(f^{-1}(cl_s^*(V)))\subseteq U$. Hence $cl_s^*(f^{-1}(V))\subseteq cl_s^*(f^{-1}(cl_s^*(V))) \subseteq U$. Thus $f^{-1}(V)$ is $I_{\tilde{g}s}$-closed and so f is $I_{\tilde{g}s}$-irresolute.

Definition 3.13 An ideal topological space (X, τ, I) is said to be $I_{\tilde{g}s}$-connected if X cannot be written as a disjoint union of two non empty $I_{\tilde{g}s}$-open subsets.

Theorem 3.14 Iff: $(X, \tau, I)\to(Y, \sigma)$ is $I_{\tilde{g}s}$-continuous surjective map and X is $I_{\tilde{g}s}$-connected, then Y is connected.

Proof. Suppose $Y =A\cup B$ where A and B are disjoint open sets in Y. S ince f is $I_{\tilde{g}s}$-continuous and surjective, $X=f^{-1}(A)\cup f^{-1}(B)$ where $f^{-1}(A)$ and $f^{-1}(B)$ are two non empty disjoint $I_{\tilde{g}s}$-open sets in X, which is a contradiction, since X is $I_{\tilde{g}s}$-connected. Hence Yis connected.

Definition 3.15 An ideal topological space (X, τ, I) is said to be $I_{\tilde{\tilde{g}}s}$-normal if for each two of non empty disjoint closed sets A and B of X, there exists disjoint $I_{\tilde{\tilde{g}}s}$-open subsets U and V of X such that A⊆U and B⊆V.

Theorem 3.16 If f : (X, τ, I)→(Y, σ) is $I_{\tilde{\tilde{g}}s}$-continuous closed injectivemap and Y is normal, then X is $I_{\tilde{\tilde{g}}s}$-normal.

Proof. Let A and B be any two disjoint closed subsets of X. Since f isclosed and injective, f(A) and f(B) are disjoint and closed subsets of Y. SinceY is normal, then there exist two disjoint open subsets Uand V of X such that f(A)⊆U and f(B)⊆V. Hence A⊆f^{-1}(U) and B ⊆ f^{-1}(V) and $f^{-1}(U)\cap f^{-1}(V)=\emptyset$. Since f is $I_{\tilde{\tilde{g}}s}$-continuous, f^{-1}(U) and f^{-1}(V) are $I_{\tilde{\tilde{g}}s}$-open in X which implies X is $I_{\tilde{\tilde{g}}s}$-normal.

Definition 3.17 A collection {A_a : a ∈Λ} of $I_{\tilde{\tilde{g}}s}$-open sets in an idealtopological space (X, τ, I) is said to be an $I_{\tilde{\tilde{g}}s}$-open cover of a subset V of X if V⊂∪{A_a: a∈Λ}.

Definition 3.18 An ideal topological space (X, τ, I) is said to be a $I_{\tilde{\tilde{g}}s}$-compact if for any $I_{\tilde{\tilde{g}}s}$-open cover {A_a: a∈Λ}, there exists a finite subset Λ_0 of Λ of X such that X–∪{A_a: a∈Λ_0} ∈I.

Theorem 3.19 If f: (X, τ, I)→(Y, σ) is $I_{\tilde{\tilde{g}}s}$-continuous surjective function and X is $I_{\tilde{\tilde{g}}s}$-compact space, then f(X) is anf(I)-compact.

Proof. Assume thatf : (X, τ, I) →(Y, σ) is a $I_{\tilde{\tilde{g}}s}$-continuous surjective function and X is $I_{\tilde{\tilde{g}}s}$-compact space. Let {A_a: a∈Λ} be an open cover of Y. Then{$f^{-1}(A_a)$:a∈Λ}is an $I_{\tilde{\tilde{g}}s}$-open cover of X. Since X is $I_{\tilde{\tilde{g}}s}$-compact, then there exists a finite subset Λ_0 of Λ of X such that X–∪ {$f^{-1}(A_a)$:a∈Λ_0} ∈I. Hence Y–∪{A_a: a∈Λ_0}∈f(I) and so (Y, σ) is f(I)-compact.

4. Maximal $I_{\tilde{\tilde{g}}s}$-closed sets:

This section is to introduce and investigate the properties of maximal $I_{\tilde{\tilde{g}}s}$-closed sets in ideal topological spaces.

Definition 4.1 A proper nonempty $I_{\tilde{\tilde{g}}s}$-closed(resp. $I_{\tilde{\tilde{g}}s}$-open) subset Fof an ideal topological space (X, τ, I) is said to be maximal-closed (resp. maximal-open) if any $I_{\tilde{\tilde{g}}s}$-closed set (resp. $I_{\tilde{\tilde{g}}s}$-open) containing F is either X or F.

Example 4.2 LetX={a, b, c, d}, τ ={∅,{a},{b, c},{a, b, c}, X} and I={∅,{a}}. Then $I_{\tilde{\tilde{g}}s}$-closed sets are ∅, {a},{d},{a, d},{b, c}, {b, d},{c, d},{a, b, c},{a, b, d},{a, c, d},{b, c, d}, X. Here {a, b, c},{a, b, d},{a, c, d}and{b, c, d}are maximal-closed sets. Also {a, b, c}and{b, c, d}are maximal $I_{\tilde{\tilde{g}}s}$-open sets.

Remark 4.3 If Fif maximal $I_{\tilde{\tilde{g}}s}$-closed set (resp. maximal $I_{\tilde{\tilde{g}}s}$-open set), then F is $I_{\tilde{\tilde{g}}s}$-closed (resp. $I_{\tilde{\tilde{g}}s}$-open). But converse need not be true.

Example 4.4 LetX={a, b, c, d}, τ ={∅,{a},{b, c},{a, b, c}, X} and I={∅,{a}}. Then $I_{\tilde{\tilde{g}}s}$-closed sets are ∅,{a},{d},{a, d},{b, c},{b, d},{c, d},{a, b, c},{a, b, d},{a, c, d},{b, c, d}, X. Here {a} is a $I_{\tilde{\tilde{g}}s}$-closed set but not a maximal $I_{\tilde{\tilde{g}}s}$-closedset. Also the {d} is a $I_{\tilde{\tilde{g}}s}$-open set but not a maximal $I_{\tilde{\tilde{g}}s}$-open set.

Theorem 4.5 Let (X, τ, I) be an ideal topological space, then the followingstatements are true:

i) Let Fbe a maximal $I_{\tilde{\tilde{g}}s}$-closed set and G be a $I_{\tilde{\tilde{g}}s}$-closed set. Then F∪G=X or G⊂F.
ii) Let F and G be maximal $I_{\tilde{\tilde{g}}s}$-closed sets. Then F∪G=X or G=F.

Proof.(i). Assume that F is a maximal $I_{\tilde{\tilde{g}}s}$-closed set and G is a $I_{\tilde{\tilde{g}}s}$-closed set. If F ∪ G = X, then there is nothing to prove. Assume that F∪G ≠ X. Since F⊂F∪G and by theorem 2.5, we have F∪G is a $I_{\tilde{\tilde{g}}s}$-closed set. Since F is a maximal $I_{\tilde{\tilde{g}}s}$-closed set, we have F∪G=X or F∪G=F. Hence F∪G=F and so G⊂F. (ii). Assume that F and G are maximal $I_{\tilde{\tilde{g}}s}$-closed sets. If F∪G=X, then there is nothing to prove. Assume that F∪G≠X. Then by part (i),we have F ⊂ G and G ⊂ F. Hence F=G.

Definition 4.6 A functionf: (X, τ, I) → (Y, σ) is said to be maximal $I_{\tilde{\tilde{g}}s}$-continuous if $f^{-1}(V)$ is maximal $I_{\tilde{\tilde{g}}s}$-closed in X for every closed set V of Y.

Example 4.7 LetX=Y={a, b, c}, τ ={∅, {a},X}, σ={∅,{b}, Y} and I={∅, {a}, {b},{a, b}}. Define f: (X, τ, I)→(Y, σ) by f(a) =c, f(b) =a and f(c)=b. Then f is maximal $I_{\tilde{\tilde{g}}s}$-continuous function.

Theorem 4.8 A subsetAof an ideal space (X, τ, I) is maximal $I_{\tilde{\tilde{g}}s}$-continuous if and only if $f^{-1}(V)$ is maximal $I_{\tilde{\tilde{g}}s}$-open in X for every open set V of Y.

Proof. Proof is obvious.

Theorem 4.9 If f: (X, τ, I)→(Y, σ) is surjective maximal $I_{\tilde{\tilde{g}}s}$-continuousfunction, then f is $I_{\tilde{\tilde{g}}s}$-continuous.

Proof. Letf : (X, τ, I)→(Y, σ) be a surjective maximal $I_{\tilde{\tilde{g}}s}$-continuousfunction. The inverse image of f and Y are always $I_{\tilde{\tilde{g}}s}$-closed sets in X. Let V be a proper closed set in Y. Now f is a maximal $I_{\tilde{\tilde{g}}s}$-continuous functionimplies $f^{-1}(V)$ is a maximal $I_{\tilde{\tilde{g}}s}$-closed set in X. Since every maximal $I_{\tilde{\tilde{g}}s}$-closed set is a $I_{\tilde{\tilde{g}}s}$-closed set, then f is $I_{\tilde{\tilde{g}}s}$-continuous.

Example 4.10 LetX=Y =Z={a, b, c}, τ ={∅,{a, b}, X}, σ ={∅,{a}, Y} and η ={∅, {a},{a, b}, Z}, I ={∅} and J ={∅}. Definef : (X, τ, I)→(Y, σ) by f(a) = c, f(b) = a, f(c) = b and define g :(Y, σ, J)→(Z, η) by g(a) = a, g(b) = b, g(c) = c. Then f andg are maximal-continuous function, but g∘f: (X, σ, I)→(Z, η) is not a maximal $I_{\tilde{\tilde{g}}s}$-continuous, since $(g \circ f)^{-1}(\{c\}) = f^{-1}(g^{-1}(\{c\})) = f^{-1}(\{c\}) = \{a\}$ is not $I_{\tilde{\tilde{g}}s}$-closed in X whenever {c} is closed in Z.

Theorem 4.11 Letf: (X, τ, I)→(Y, σ) be a maximal $I_{\tilde{\tilde{g}}s}$-continuous function and g : (Y, σ, J)→(Z, μ) be a surjective continuous function. Then g∘f: (X, τ, I)→(Z, μ) is a maximal $I_{\tilde{\tilde{g}}s}$-continuous function.

Proof. Let V be a nonempty proper closed set in Z. Since gis continuous, then g^{-1}(V) is a nonempty proper closed set in Y. Now f is maximal $I_{\tilde{\tilde{g}}s}$-continuous implies $f^{-1}(g^{-1}(V))$ = (gæ%f)$^{-1}$(V) is a maximal $I_{\tilde{\tilde{g}}s}$-closed setin X. Hence gæ%fis a maximal $I_{\tilde{\tilde{g}}s}$-continuous function.

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