Strong forms of T*- Intuitionistic Generalized Continuous Map in intuitionistic Topological Spaces

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(Received: 9 / 1 / 2012 ---- Accepted: 13 / 3 / 2012)

Abstract
The aim of this paper is to introduce three new classes of maps called T^*- intuitionistic gc-irresolute map,strongly intuitionistic generalized continuous maps and perfectly intuitionistic generalized continuous maps in intuitionistic topological spaces and study some of their properties and relations among them . And T^* it is topology defined by $T^* = \{U: Icl^*(\bar{U}) = (\bar{U})\}$.

Key words: T^*-intuitionistic gc-irresolute maps,strongly T^*-intuitionistic generalized continuous maps , perfectly T^*-intuitionistic generalized continuous maps in intuitionistic topological spaces .

Introduction
Generalization of the concept of generalized closed sets is given by Levin, N.[5] . Dunham, W. [2] introduced generalized closure operator $cl^*$and defined a topology called T^*-topology. Pushpalatha, A. Eswaran, S. and Rajar, P.[9] introduced and investigated T^*-generalized-closed sets. Eswaran, S. and Pushpalatha,A. [3]studied and introduced T^*-generalized-continuous maps in a topological spaces. Gananambal,Y.[4] studied generalized-closed sets in topological spaces .

Pushpalatha, A. and Eswaran, S . [8] introduced T^*-generalized-closed sets,T^*- generalized-continuous maps, perfectly generalized-continuous maps and strongly generalized-continuous maps respectively. Raouf, G. A. [10] studied intuitionistic generalized-closed sets and some kinds in intuitionistic topological space.

In this paper, we introduce three new classes of maps between intuitionistic topological spaces (ITS) namely T^*- intuitionistic gc-irresolute maps, strongly T^*-intuitionistic g-continuous maps and perfectly T^*-intuitionistic g-continuous maps and study their properties. Throughout this paper(X,T^*) and (Y,T^*) (or simply X and$Y$) represent non-empty intuitionistic topological spaces (ITS) on which no separation axioms are assumed,unless otherwise mentioned. Let A be an IS in (X,T^*) , we denote the closure of A (respectively the generalized closure operator is defined by the intersection of all Ig-closed contining A , and A^c represent closure of A and complement of A to an intuitionistic topological spaces (ITS) on T^* by cl (A) (respectively cl^* (A)) .

Preliminaries
We recall the following definitions which are needed in our work

Let X be a non-empty set, and let A and B be IS having the form $A = \langle x, A_1, A_2\rangle$; $B = \langle x, B_1, B_2\rangle$ respectively. Furthermore, let $\{A_i: i \in I\}$ be an arbitrary family of IS in$X$, where $A_i = \langle x, A_i^{(1)}, A_i^{(2)}\rangle$, then :

1) $\tilde{\emptyset} - \langle x, \emptyset, X\rangle$; $\tilde{X} = \langle x, X, \emptyset\rangle$.
2) $A \subseteq B, iff\ A_1 \subseteq B_1\ and\ A_2 \supseteq B_2$.
3) The complement of A is denoted by $\bar{A}$ and defined by $\bar{A} = \langle x, A_2, A_1\rangle$.
4) $\cup A_i = \langle x, \cup A_i^{(1)}, \cap A_i^{(2)}\rangle, \cap A_i = \langle x, \cap A_i^{(1)}, \cup A_i^{(2)}\rangle$[5]. Let X and Y be two non-empty sets and $f: X \to Y$ be a function. If $B = \langle y, B_1, B_2\rangle$ is IS in Y, then the pre image of B under f denoted by $f^{-1}(B)$ is IS in X defined by$f^{-1}(B) = \langle x, f^{-1}(B_1), f^{-1}(B_2)\rangle$.[1]. An intuitionistic topology (IT, for short) on a non-empty set X, is a family T of IS in X containing $\tilde{\emptyset}, \tilde{X}$ and closed under arbitrary unions and finitely intersections. The pair(X,T) is called an intuitionistic topological space (ITS, for short) [1] . A subset A of intuitionistic topological spaces (ITS, for short) (X,T) is said to be generalized closed (g-closed) in X if $Icl(A) \subseteq U$ whenever $A \subseteq U$ and U is I open in X. A subset A is called generalized open (g-open) in X if its complement A^c is g-closed [5]. For the subset A of ITS (X,T), the intuitionistic generalized closure operator Icl^* is defined by the intersection of all Ig-closed sets containing A[2] .

A subset A of ITS (X,T), the topology T^* is defined by$T^* = \{U: Icl^*(\bar{U}) = (\bar{U})\}$ [2]. A subset A of ITS (X,T) is called T^*-generalized-closed sets (T^*-Ig-closed) if $cl^*(A) \subseteq U$ whenever $A \subseteq U$ and U is T^*-I-open in X. The complement of T^*-I generalized-closed set is called the T^*-I generalized-open set (T^*-Ig-open) [9]. A collection $\{A_i: i \in I\}$ of g-open sets in a topological space (X,T) is called a Ig-open cover of a subset B if $B \subset U\{A_i : i \in I\}$ [2]. A map $f:(X,T) \rightarrow (Y,\tau)$ is called continuous if $f^{-1}(V)$ is I-closed (or I-open) in X for every y I-closed set (or I-open set) V in Y [10] . A map $f:(X,T) \rightarrow (Y,\tau)$ is called generalized continuous (Ig-continuous) if $f^{-1}(V)$ is Ig-closed in X for every I-closed set in Y [10]. A map $f:(X,T) \rightarrow (Y,\tau)$ is said to be gc-irresolute if $f^{-1}(V)$ is Ig-closed in X for every Ig-closed set in Y [7]. A map $f:(X,T) \rightarrow (Y,\tau)$ is said to be strongly generalized-continuous (strongly Ig-continuous) if $f^{-1}(V)$ is Iopen set in X for every Ig-open set in Y [10] . A map $f:(X,T) \rightarrow (Y,\tau)$ is said to be perfectly generalized-continuous (perfectly Ig-continuous) if $f^{-1}(V)$ is both Iopen and I-closed set in X for every Ig-open set in Y[8].

A map $f:(X,T) \rightarrow (Y,\tau)$is called T^*-generalized continuous (T^*-Ig-continuous) if $f^{-1}(V)$ is T^*-Ig-closed set in X for every Ig-closed set in Y [9] .

Proposition 2.1 [9]

Every I-closed set in X is T^*-Ig-closed

Proof

Let A be an Iclosed set in X. Let $A \subseteq U$ where U is any T^*-Iopen set in X. Since A is an Iclosed then $Icl(A) = A \subseteq U$ but $Icl^*(A) \subseteq Icl(A)$. Thus, we have $Icl^*(A) \subseteq U$ whenever $A \subseteq U$. Therefore, A is T^*-Ig-closed .

Proposition 2.2 [9]

Every Ig-closed set is T^*-Ig-closed .

Proof

Let A be Ig-closed set in X. Let $A \subseteq U$ where U is T^*-Iopen in X. Then $Icl(A) \subseteq U$, since A is Ig-closed, $Icl^*(A) \subseteq Icl(A)$. Therefore, $Icl^*(A) \subseteq U$. Hence A is T^*-Ig-closed .

T^*-intuitionistic gc - irresolute maps in intuitionistic topological spaces

In this section, we introduce a new class of map called T^*- intuitionistic gc- irresolute (T^*-Igc-irresolute) maps . which is included in the class of T^*- intuitionistic g-continuous (T^*-Ig-continuous) maps . We investigate some basic properties also.

Definition 3.1

A map $f:(X,T) \rightarrow (Y,\tau)$, where (X,T) and (Y,τ) are ITS is called T^*-Igc-irresolute if the inverse image of every T^*-Ig-closed set in Y is T^*-Ig-closed set in X.

Theorem 3.2

The space (X,T) and (Y,τ) are T^*-Igc-irresolute if and only if the inverse image of every T^*-Ig-open set in Y is T^*-Ig-open in X.

Proof

Assume that f is T^*-Igc-irresolute. Let A be any T^*-Ig-open set in Y. Then A^c is T^*-Ig-closed set in Y. Since f is T^*-Igc-irresolute, $f^{-1}(A^c)$ is T^*-Ig-closed set in X. But $f^{-1}(A^c) = (f^{-1}(A))^c$ so $f^{-1}(A)$ is T^*-Ig-open set in X. Hence the inverse image of every T^*-Ig-open set in Y is T^*-Ig-open set in X.

Assume that the inverse image of every T^*-Ig-open set in Y is T^*-Ig-open set in X. Let A be any T^*-Ig-closed set in Y. Then A^c is T^*-Ig-open set in Y. Then $f^{-1}(A^c)$ is T^*-Ig-open set in X. But $f^{-1}(A^c) = (f^{-1}(A))^c$ so $f^{-1}(A)$ is T^*-Ig-closed set in X. Therefore, f is T^*-Igc-irresolute .

Theorem 3.3

A map $f:X \rightarrow Y$ is T^*- Igc-irresolute if and only if it is T^*-Ig-continuous .

Proof

Since f is T^*-Igc-irresolute. Let V be any Ig-closed set in Y. By proposition 2.2, V is T^*-Ig-closed set in Y. Since f is T^*-Igc-irresolute, then $f^{-1}(V)$ is T^*-Ig-closed in X. Therefore, f is T^*-Ig-continuous.

Since f is T^*-Ig-continuous. Let V be any Ig-closed set in Y. By properties 2.2, V is T^*-Ig-closed set in Y. f is T^*-Ig-continuous, then $f^{-1}(V)$ is T^*-Ig-closed set in X. Therefore, f is T^*-Igc-irresolute.

Proposition 3.4

Let X, Y and Z are an intuitionistic topological spaces . For any T^*-Igc-irresolute map $f:X \rightarrow Y$and any T^*-Ig-continuous map$g:Y \rightarrow Z$, the composition $g \circ f:X \rightarrow Z$ is T^*-Ig-continuous .

Proof

Let V be any Ig-closed set in Z. Since g is T^*-Ig-continuous, $g^{-1}(V)$ is T^*-Ig-closed set in Y. Since f is T^*-Igc-irresolute, $f^{-1}(g^{-1}(V))$ is T^*-Ig-closed set in X. But $f^{-1}(g^{-1}(V)) = (g \circ f)^{-1}(V)$. Therefore, $g \circ f$ is T^*-Ig-continuous.

Proposition 3.5

If $f:X \rightarrow Y$ from intuitionistic topological space (X,T^*) into intuitionistic topological space (Y,τ^*) is bijective, Ig-open and T^*-Ig-continuous then f is T^*-Igc-irresolute .

Proof

Let V be any T^*-Ig-closed set in Y. Let $f^{-1}(V) \subseteq U$ where V is Ig-open set in X. Therefore, $V \subseteq f(U)$ holds .

Since $f(U)$ is Ig-open and V is T^*-Ig-closed set in Y, $cl(V) \subseteq f(U)$ holds and hence$f^{-1}(cl(V)) \subseteq U$. Since f is T^*-Ig-continuous and $cl(V)$ is Ig-closed set in Y. $cl(f^{-1}(cl(V))) \subseteq U$ and so $cl(f^{-1}(V)) \subseteq U$. Therefore, $f^{-1}(V)$ is T^*-Ig-closed set in X. Hence f is T^*-Igc-irresolute.

Strongly T^*- intuitionistic g- continuous maps an intuitionistic topological spaces

Levine, N. [5] introduced and investigated strongly I continuous and strongly Ig-continuous in intuitionistic topological spaces respectively.

In this section we introduce anew kind of amap forms of intuitionistic continuous maps an intuitionistic topological spaces namely strongly T^*- intuitionistic g – continuous (T^*-Ig-continuous) maps and related to other kind of maps which are defined in this work .

Definition 4.1

A map $f:(X,T) \to (Y,\tau)$, where (X,T) and (Y,τ) are ITS is called strongly T^*- intuitionistic g - continuous if the inverse image of every T^*-Ig-open set (or T^*-Ig-closed set) in Y is Ig-open (or Ig-closed) in X.

Proposition 4.2

If a map $f: X \to Y$ from an intuitionistic topological space (X,T^*) into an intuitionistic topological space (Y,τ^*) is strongly T^*-Ig-continuous then it is T^*-Ig-continuous .

Proof

Since f is strongly T^*-Ig-continuous. Let A be any Ig-closed set in Y. By proposition 2.2, A is T^*-Ig-closed set in Y. Since f is strongly T^*-Ig-continuous, $f^{-1}(A)$ is Ig-closed in X. Therefore, f is T^*-Ig-continuous .

The converse of the above proposition need not be true as the following example shows.

Example 4.3

Let $X = \{1,2,3\}; T = \{\tilde{\emptyset}, \tilde{X}, A, B\}$ where$A = \langle x, \{2\}, \{1,3\}\rangle$ and$B = \langle x, \{2\}, \emptyset\rangle$.Let $Y = \{a, b, c\}; \tau = \{\tilde{\emptyset}, \tilde{Y}, C\}$ where $C = \langle y, \{a\}, \emptyset\rangle$. Define a mapping $f: X \to Y$ by $f(2) = a$,$f(3) = b$ and $f(1) = c$. Then f is T^*-Ig-continuous. But f is not strongly T^*-Ig-continuous, since $D = \langle y, \{a\}, \{b, c\}\rangle$ is T^*-Ig-closed set in Y, $A = f^{-1}(D) = \langle x, \{2\}, \{1,3\}\rangle$ is not g-closed set in X.

Theorem 4.4

A mapping $f: X \to Y$ from an intuitionistic topological space (X,T^*) into an intuitionistic topological space (Y,τ^*) is strongly T^*-Ig-continuous if and only if the inverse image of every T^*-Ig-closed set in Y is Ig-closed in X.

Proof

Since f is strongly T^*-Ig-continuous. Let V be any T^*-Ig-closed set in Y. Then V^c is T^*-Ig-open set in Y. Since f is strongly T^*-Ig-continuous, $f^{-1}(V^c)$ is Ig-open in X. But $f^{-1}(V^c) = (f^{-1}(V))^c$ and so $f^{-1}(V)$ is Ig-closed set in X.

Conversely

Since the inverse image of every T^*-Ig-closed set in Y is Ig-closed set in X. Let A be any T^*-Ig-open set in Y. Then A^c is T^*-Ig-closed set in Y. Then $f^{-1}(A^c)$ is Ig-closed set in X. But$f^{-1}(A^c) = (f^{-1}(A))^c$ so $f^{-1}(A)$ is Ig-open set in X. Therefore, f is strongly T^*-Ig-continuous .

Proposition 4.5

If a mapping $f: X \to Y$ is strongly T^*-Ig-continuous and a mapping $g: Y \to Z$ is T^*-Ig-continuous then the composition $g \circ f: X \to Z$ is T^*-Ig-continuous.

Proof

Let A be any Ig-closed set in Z. Since g is T^*-Ig-continuous, $g^{-1}(A)$ is T^*-Ig-closed set in Y. Since f is strongly T^*-Igc-continuous, $f^{-1}(g^{-1}(A))$ is T^*-Ig-closed set in X .By proposition 2.2. So $f^{-1}(g^{-1}(A))$ is T^*-Ig-closed set. But $f^{-1}(g^{-1}(A)) = (g \circ f)^{-1}(A)$. Therefore, $g \circ f$ is T^*-Ig-continuous .

Proposition 4.6

If mapping $f: X \to Y$ from an intuitionistic topological space (X,T^*) into an intuitionistic topological space (Y,τ^*) is I continuous then it is strongly T^*-Ig-continuous but not conversely .

Proof

Since f is I continuous. Let A be any I-closed set in Y, then $f^{-1}(A)$ is I-closed set in X. By proposition 2.2, A is T^*-Ig-closed. Since every I-closed set is

Ig-closed then $f^{-1}(A)$ is Ig-closed. Hence f is strongly T^*-Ig-continuous .

The Converse of the above proposition need not be true as seen from the following example .

Example 4.7

Let $X = \{a, b, c\}; T = \{\tilde{\emptyset}, \tilde{X}, A, B\}$ where $A = \langle x, \{a\}, \{b, c\}\rangle$ and $B = \langle x, \{b, c\}, \{a\}\rangle$. Let $Y = \{1,2,3\}; \tau = \{\tilde{\emptyset}, \tilde{Y}, C, D\}$ where $C = \langle y, \{1\}, \{2,3\}\rangle; D = \langle y, \{1\}, \emptyset\rangle$. Define a mapping $f: X \to Y$ by $f(a) = f(c) = 1$ and $f(b) = 2$. We can see that f is strongly T^*-Ig-continuous. We can see also that f is not continuous, since $\bar{C} = \langle y, \{2,3\}, \{1\}\rangle$ is closed set in Y then $f^{-1}(\bar{C}) = \langle x, \{b\}, \{a, c\}\rangle$ is not closed set in X.

Proposition 4.8

If a mapping $f: X \to Y$ from an intuitionistic topological space (X, T^*) into an intuitionistic topological space (Y, τ^*) is Ig-continuous then it is strongly T^*-Ig-continuous .

Proof

Let $f: X \to Y$ be Ig-continuous .

Let A be I closed set in Y. Since f is Ig-continuous , then $f^{-1}(A)$ is Ig-closed set in X.By proposition 2.2 , A is T^*-Ig-closed set in Y. Therefore f is strongly T^*-Ig-continuous .

The converse of the proposition need not be true as the following example shows.

Example 4.9

Let $X = \{1,2,3\}; T = \{\tilde{\emptyset}, \tilde{X}, A, B\}$ where $A = \langle x, \{1\}, \{2,3\}\rangle$ and $B = \langle x, \{1\}, \emptyset\rangle$. Let $Y = \{a, b, c\}; \tau = \{\tilde{\emptyset}, \tilde{Y}, C, D\}$ where $C = \langle y, \{a\}, \{b, c\}\rangle$ and $D = \langle y, \{b, c\}, \{a\}\rangle$. Define a mapping $f: X \to Y$ by $f(1) = f(3) = a$ and $f(2) = b$. Then f is strongly T^*-Ig-continuous. Since for the T^*-Ig-closed set $E = \langle y, \{b\}, \emptyset\rangle$ in Y, is $f^{-1}(E) = \langle x, \{2\}, \emptyset\rangle$ is Ig-closed set in X. But f is not Ig-continuous, because E is not closed set in Y.

Proposition 4.10

If a map $f: X \to Y$ from an intuitionistic topological space (X, T^*) into an intuitionistic topological space (Y, τ^*) is strongly T^*-Ig-continuous then it is T^*-Igc-irresolute but not conversely.

Proof

Let f is strongly T^*-Ig-continuous map. Let A be a T^*-Ig-closed set in Y, then $f^{-1}(A)$ is Ig-closed in X. By proposition 2.2, $f^{-1}(A)$ is T^*-Ig-closed set in X. Therefore, f is T^*-Igc –irresolute .

The Converse of the above proposition need not be true as seen from the following example .

Example 4.11

Let $X = \{1,2,3\}; T = \{\tilde{\emptyset}, \tilde{X}, A, B\}$ where $A = \langle x, \{3\}, \{1,2\}\rangle$ and $B = \langle x, \{3\}, \emptyset\rangle$. Let $Y = \{a, b, c\}; \tau = \{\tilde{\emptyset}, \tilde{Y}, C\}$ where $C = \langle y, \{b\}, \emptyset\rangle$. Define a mapping $f: X \to Y$ by $f(3) = b; f(2) = a$ and $f(1) = c$. Then f is T^*-Igc-irresolute. But f is not strongly T^*-Ig-continuous, since C is T^*-Ig-closed closed in Y, $B = f^{-1}(C) = \langle x, \{3\}, \emptyset\rangle$ is not Ig-closed in X.

Perfectly T^*- intuitionistic g -continuous maps an intuitionistic topological spaces

In this section, we introduce a new kind of maps called perfectly T^*- intuitionistic g- continuous (perfectly T^*-Ig-continuous) maps and related of other kind of maps which are defined in this work.

Definition 5.1

A map $f: (X, T) \to (Y, \tau)$, where (X, T) and (Y, τ) are ITS is called perfectly T^*-Ig-continuous if the inverse image of every T^*-Ig-closed set in Y is both Ig-open and Ig-closed in X.

Proposition 5.2

If a map $f: X \to Y$ from an intuitionistic topological space (X, T^*) into an intuitionistic topological space (Y, τ^*) is perfectly T^*-Ig-continuous then it is strongly T^*-Ig-continuous but not converse.

Proof

Since f is perfectly T^*-Ig-continuous. Let V be any T^*-Ig-closed set in Y, then $f^{-1}(V)$ is Ig-closed in X. Therefore, f is strongly T^*-Ig-continuous .

The Converse of the above proposition need not be true as seen from the following example shows.

Example 5.3

Recall example 4.9. It is clear that f is strongly T^*-Ig-continuous, but not perfectly T^*-Ig-continuous.

Theorem 5.4

A map $f: X \to Y$ from an intuitionistic topological space (X, T^*) into an intuitionistic topological space (Y, τ^*) is perfectly T^*-Ig-continuous if and only if the inverse image of every T^*-Ig-closed set in Y is both Ig-open and Ig-closed in X.

Proof

Since f is perfectly T^*-Ig-continuous. Let V be any T^*-Ig-closed set in Y. Then $f^{-1}(V^c)$ is both Ig-open and Ig-closed in X. But $f^{-1}(V^c) = (f^{-1}(V))^c$ so $f^{-1}(V)$ is both Ig-open and Ig-closed in X.

Conversely

Since the inverse image of every T^*-Ig-closed set in Y is both Ig-open and Ig-closed in X. Let A be any T^*-Ig-open set in Y. Then A^c is T^*-Ig-closed set in Y, by assumption, $f^{-1}(A^c) = (f^{-1}(A))^c$ and so $f^{-1}(A)$ is both Ig-open and Ig-closed in X. Therefore, f is perfectly T^*-Ig-continuous .

Proposition 5.5

If a map $f: X \to Y$ from an intuitionistic topological space (X, T^*) into an intuitionistic topological space (Y, τ^*) is perfectly T^*-Ig-continuous then it is T^*-Igc-irresolute, but not conversely .

Proof

Since f is perfectly T^*-Ig-continuous. Let A be a T^*-Ig-closed set in Y, then $f^{-1}(A)$ is both Ig-open and Ig-closed in X. By proposition 2.2, $f^{-1}(A)$ is T^*-Ig-closed set in X. Hence f is T^*-Igc-irresolute .

The Converse of the above proposition need not be true as seen from the following example shows.

Example 5.6

Recall example 4.11. We see that f is T^*-Igc-irresolute, but not perfectly T^*-Ig-continuous .

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تعميم الدوال المستمرة القوية الشكل في الفضاءات التبولوجية الحدسية-T^*

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(تاريخ الاستلام: 9 / 1 / 2012 ---- تاريخ القبول: 13 / 3 / 2012)

الملخص

أن الهدف من هذا البحث هو أعطاء ثلاث أصناف جديدة من الدوال الحدسية وأسميناها تعميم الدوال غير القابلة للاختزال الحدسية-T^* وتعميم الدوال المستمرة القوية الحدسية-T^* وتعميم الدوال المستمرة التامة الحدسية-T^* في الفضاءات التبولوجية الحدسية ودرسنا بعض صفاتها والعلاقة بينهم .