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Intuitionistic Fuzzy $\pi g\gamma^*$ Contra Continuous Mappings

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Abstract: This paper is devoted to the study of intuitionistic fuzzy topological spaces. In this paper, we have introduced intuitionistic fuzzy πgγ* contra continuous mappings. Also, we have studied some of their properties of intuitionistic fuzzy πgγ* contra continuous mappings in intuitionistic fuzzy topological spaces. Identified few examples for intuitionistic fuzzy πgγ* contra continuous mappings. Studied the cases of IF contra continuous mapping, IFS contra continuous mapping, IFP contra continuous mapping, IFαcontra continuous mapping, IFγcontra continuous mapping, IFG contra continuous mapping and IFγ*G contra continuous mapping. Derived some properties of $cT_{1/2}$ space. Also studied the case in $gT_{1/2}$ space. Have done some analysis on the composition of two IFπgγ* contra continuous mappings.

Keywords: Intuitionistic fuzzy topology, intuitionistic fuzzy $\pi g\gamma^*$ closed set, intuitionistic fuzzy $\pi g\gamma^*$ continuous mapping and intuitionistic fuzzy $\pi g\gamma^*$ contra continuous mappings.

I. INTRODUCTION

The concept of intuitionistic fuzzy sets was introduced by Atanassov[1] using the notion of fuzzy sets. On the other hand Coker[2] introduced intuitionistic fuzzy topological spaces using the notion of intuitionistic fuzzy sets. In this paper we introduce intuitionistic fuzzy $\pi g\gamma^*$ contracontinuous mappings and studied some of their basic properties. We provide some relations of intuitionistic fuzzy $\pi g\gamma^*$ contracontinuous mappings between existing intuitionistic fuzzy continuous and irresolute mappings.

II. PRELIMINARIES

Definition 2.1: [1] An intuitionistic fuzzy set (IFS in short) G in X is an object having the form
$G = \{\langle x, \mu_G(x), \nu_G(x) \rangle / x \in X\}$
where the functions $\mu_G(x): X \to [0, 1]$ and $\nu_G(x): X \to [0, 1]$ denote the degree of membership (namely $\mu_G(x)$) and the degree of non-membership (namely $\nu_G(x)$) of each element $x \in X$ to the set G, respectively, and $0 \le \mu_G(x) + \nu_G(x) \le 1$ for each $x \in X$. Denote by IFS(X), the set of all intuitionistic fuzzy sets in X.

Definition 2.2: [1] Suppose G_1 and $G_2$are IFSs of the form
$G_1 = \{\langle x, \mu_{G1}(x), \nu_{G1}(x) \rangle / x \in X\}$ and $G_2 = \{\langle x, \mu_{G2}(x), \nu_{G2}(x) \rangle / x \in X\}$.
Then
(a) $G_1 \subseteq G_2$if and only if $\mu_{G1}(x) \le \mu_{G2}(x)$ and $\nu_{G1}(x) \ge \nu_{G2}(x)$ for all $x \in X$
(b) $G_1 = G_2$if and only if $G_1 \subseteq G_2$and $G_2 \subseteq G_1$
(c) $G_1^c = \{\langle x, \nu_{G1}(x), \mu_{G1}(x) \rangle / x \in X\}$
(d) $G_1 \cap G_2 = \{\langle x, \mu_{G1}(x) \wedge \mu_{G2}(x), \nu_{G1}(x) \vee \nu_{G2}(x) \rangle / x \in X\}$
(e) $G_1 \cup G_2 = \{\langle x, \mu_{G1}(x) \vee \mu_{G2}(x), \nu_{G1}(x) \wedge \nu_{G2}(x) \rangle / x \in X\}$

Forthe sake of simplicity, we shall use the notation$G_1 = \langle x, \mu_{G1}, \nu_{G1}\rangle$ instead of $G_1 = \{\langle x, \mu_{G1}(x), \nu_{G1}(x) \rangle / x \in X$. Also forthe sake of simplicity, we shall use the notation$G_1 = \{\langle x, (\mu_{G1}, \mu_{G2}), (\nu_{G1}, \nu_{G2})\rangle\}$ instead of $G_1 = \langle x, (G_1/\mu_{G1}, B/\mu_{G2}), (G_1/\nu_{G1}, B/\nu_{G2}) \rangle$.

The intuitionistic fuzzy sets $0_\sim = \{\langle x, 0, 1 \rangle / x \in X\}$ and $1_\sim = \{\langle x, 1, 0 \rangle / x \in X\}$ are respectively the empty set and the whole set of X.

Definition 2.3: [4] An intuitionistic fuzzy topology (IFT in short) on X is a family τ of IFSs in X satisfying the following axioms.

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(i) $0_\sim, 1_\sim \in \tau$
(ii) $G_1 \cap G_2 \in \tau$ for any $G_1, G_2 \in \tau$
(iii) $\cup G_i \in \tau$ for any family $\{ G_i / i \in J \} \subseteq \tau$.

In this case the pair (X, τ) is called an intuitionistic fuzzy topological space (IFTS in short) and any IFS in τ is known as an intuitionistic fuzzy open set (IFOS in short) in X.
The complement G^c of an IFOS G in IFTS (X, τ) is called an intuitionistic fuzzy closed set (IFCS in short) in X.

Definition 2.4:[4] Suppose (X, τ) is an IFTS and $G = \langle x, \mu_G, \nu_G \rangle$ is an IFS in X. Then the intuitionistic fuzzy interior and intuitionistic fuzzy closure are defined by
$int(G) = \cup \{ G_1 / G_1$ is an IFOS in X and $G_1 \subseteq G \}$,
$cl(G) = \cap \{ G_1 / G_1$ is an IFCS in X and $G \subseteq G_1 \}$.
Note that for any IFS G in (X, τ), we have $cl(G^c) = [int(G)]^c$ and $int(G^c) = [cl(G)]^c$.

Definition 2.5:[6] An IFS $G = \{ \langle x, \mu_G, \nu_G \rangle \}$ in an IFTS (X, τ) is called an
(i) *intuitionistic fuzzy semi open set* (IFSOS in short) if $G \subseteq cl(int(G))$,
(ii) *intuitionistic fuzzy α-open set* (IFαOS in short) if $G \subseteq int(cl(int(G)))$,
(iii) intuitionistic fuzzy regular open set (IFROS in short) if $G = int(cl(G))$,

Definition 2.6: [7] The union of IFROSs is called intuitionistic fuzzy π-open set (IFπOS in short) of an IFTS (X, τ). The complement of IFπOS is called intuitionistic fuzzy π -closed set (IFπCS in short).

Definition 2.7:[6] An IFS $G = \langle x, \mu_G, \nu_G \rangle$ in an IFTS (X, τ) is called an
(i) *intuitionistic fuzzy semi closed set* (IFSCS in short) if $int(cl(G)) \subseteq G$,
(ii) *intuitionistic fuzzy α-closed set* (IFαCS in short) if $cl(int(cl(G)) \subseteq G$,
(iii) intuitionistic fuzzy regular closed set (IFRCS in short) if $G = cl(int((G)$.

Definition 2.8:[5] An IFS G of an IFTS (X, τ) is an
(i) intuitionistic fuzzy γ-open set (IFγOS in short) if $G \subseteq int(cl(G)) \cup cl(int(G))$,
(ii) intuitionistic fuzzy γ-closed set (IFγCS in short) if $cl(int(G)) \cap int(cl(G)) \subseteq G$.

Definition 2.9:[11] SupposeGis an IFS in an IFTS (X, τ). Then
$sint(G) = \cup \{ G_1 / G_1$ is an IFSOS in X and $G_1 \subseteq G \}$,
$scl(G) = \cap \{ G_1 / G_1$ is an IFSCS in X and $G \subseteq G_1 \}$.
Note that for any IFS G in (X, τ), we have $scl(G^c)=(sint(G))^c$ and $sint(G^c) = (scl(G))^c$.

Definition 2.10:[10] An IFS A in an IFTS (X, τ) is an
(i) intuitionistic fuzzy generalized closed set (IFGCS in short) if $cl(G) \subseteq U$ whenever $G \subseteq U$ and U is an IFOS in X.
(ii) intuitionistic fuzzy regular generalized closed set (IFRGCS in short) if $cl(G) \subseteq U$whenever $G \subseteq U$ and U is an IFROS in X.

Definition 2.11:[11] An IFS G in an IFTS (X, τ) is called an intuitionistic fuzzy generalized semi closed set (IFGSCS in short) if $scl(G) \subseteq U$ whenever $G \subseteq U$ and U is an IFOSin (X, τ).
Definition 2.12:[10] An IFS G in (X, τ) is called an intuitionistic fuzzy $\pi g\gamma^*$ closed set (IF$\pi g\gamma^*$CS in short) if $cl(int(G)) \cap int(cl(G)) \subseteq U$ whenever $G \subseteq U$ and U is an IFπOS in (X, τ). The family of all IF$\pi g\gamma^*$CSs of an IFTS (X, τ) is denoted by IF$\pi g\gamma^*$C(X).

Result 2.13: [10]Every IFCS, IFGCS, IFRCS, IFαCS is an IF$\pi g\gamma^*$CS but the converses may not be true in general.

Definition 2.14:[10] An IFS Gis called an intuitionistic fuzzy $\pi g\gamma^*$open set (IF$\pi g\gamma^*$OS in short) in (X, τ) if the complement G^c is an IF$\pi g\gamma^*$CS in X.
The family of all IF$\pi g\gamma^*$OSs of an IFTS (X, τ) is denoted by IF$\pi g\gamma^*$O(X).

Definition 2.15:[5] Suppose *f* is a mapping from an IFTS (X, τ) into an IFTS (Y, σ). Then *f* is called intuitionistic fuzzy contra continuous (IF contra continuous in short) if $f^{-1}(G) \in IFCS(X)$ for every $G \in \sigma$.

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Definition 2.16:[6] Suppose f is a mapping from an IFTS (X, τ) into an IFTS (Y, σ). Then f is called
(i) intuitionistic fuzzy semi contra continuous (IFS contra continuous in short) iff $f^{-1}(G) \in$ IFSCS(X) for every $G \in \sigma$.
(ii) intuitionistic fuzzy α contra continuous (IFαcontra continuous in short) if $f^{-1}(G) \in$ IFαCS(X) forevery $G \in \sigma$.
(iii) intuitionistic fuzzy pre contra continuous (IFP contra continuous in short) if $f^{-1}(G) \in$IFPCS(X) forevery $G \in \sigma$.

Definition 2.17:[5]A mapping $f : (X_1, \tau) \to (X_2, \sigma)$ is called an *intuitionistic fuzzy γcontra continuous* (IFγcontra continuous in short) if $f^{-1}(G)$ is an IFγCS in (X_1, τ) for every $G \in \sigma$.

Definition 2.18:[9] Suppose f is a mapping from an IFTS (X_1, τ) into an IFTS (X_2, σ). Then f is called an intuitionistic fuzzy generalized contra continuous (IFG contra continuous in short) if $f^{-1}(G) \in$ IFGCS(X) for every IFOS G in X_2.

Definition 2.19:[5]An IFTS (X, τ) is called an intuitionistic fuzzy $\pi\gamma$*c$T_{1/2}$ (in short IF$\pi\gamma$*c$T_{1/2}$) space if every IF$\pi g\gamma$*CS in X is an IFCS in X.

Definition 2.20:[6]An IFTS (X, τ) is an intuitionistic fuzzy $\pi\gamma$*g$T_{1/2}$ (IF$\pi\gamma$*g$T_{1/2}$) space if every IF$\pi g\gamma$*CS is an IFGCS in X.

Definition 2.21:[7]An IFTS (X, τ) is called an intuitionistic fuzzy $\pi\gamma$*$T_{1/2}$ (in short IF$\pi\gamma$*$T_{1/2}$) space if every IF$\pi g\gamma$*CS in X is an IFγCS in X.

III. INTUITIONISTIC FUZZY $\pi g\gamma$*CONTRA CONTINUOUS MAPPINGS

In this section we introduce intuitionistic fuzzy $\pi g\gamma$* contra continuous mappings and studied some of its properties.

Definition 3.1: A mapping $f : (X_1, \tau) \to (X_2, \sigma)$ is called an*intuitionistic fuzzy* πgγ*contra *continuous* (IF$\pi g\gamma$*contra continuous in short) mapping if $f^{-1}(G)$ is an IF$\pi g\gamma$*CS in (X, τ) for every IFOSG of (X_2, σ).

Example3.2: Suppose $X_1 = \{a, b\}$, $X_2 = \{u, v\}$ and $T_1 = \langle x_1, (0.3, 0.3), (0.6, 0.6) \rangle$, $T_2 = \langle x_2, (0.3, 0.2), (0.6, 0.7) \rangle$. Then $\tau = \{0_\sim, T_1, 1_\sim\}$ and $\sigma = \{0_\sim, T_2, 1_\sim\}$ are IFTs on X_1 and X_2 respectively. Define a mapping $f : (X_1, \tau) \to (X_2, \sigma)$by f(a) = u and f(b) = v. Then f is an IF$\pi g\gamma$*contra continuous mapping.

Theorem 3.3:*Every IF contra continuous mapping is an IF$\pi g\gamma$*contra continuous mapping but not conversely.*
Proof: Suppose$f : (X_1, \tau) \to (X_2, \sigma)$ is an IF *contra* continuous mapping. Let G be an IFOS in X_2. As f is IF *contra* continuous mapping, $f^{-1}(G)$ is an IFCS in X_1. As every IFCS is an IF$\pi g\gamma$*CS, $f^{-1}(G)$ is IF$\pi g\gamma$*CS in X_1. Hence f is an IF$\pi g\gamma$**contra* continuous mapping.

Example 3.4: Suppose$X_1 = \{a, b\}$, $X_2 = \{u, v\}$ and $T_1 = \langle x_1, (0.2, 0.2), (0.5, 0.7) \rangle$, $T_2 = \langle x_2, (0.4, 0.2), (0.5, 0.5) \rangle$. Then $\tau = \{0_\sim, T_1, 1_\sim\}$ and $\sigma = \{0_\sim, T_2, 1_\sim\}$ are IFTs on X_1 and X_2 respectively. Define a mapping $f : (X_1, \tau) \to (X_2, \sigma)$ by f(a) = u and f(b) = v. The IFS $B = \langle x_2, (0.4, 0.2), (0.5, 0.5) \rangle$ is IFOS in X_2. Then $f^{-1}(B) = \langle x_1, (0.4, 0.2), (0.5, 0.5) \rangle$is IF$\pi g\gamma$*CS in X_1 but not IFCS in X_1. *Thus* f is an IF$\pi g\gamma$* contra continuous mapping but not an IF contra continuous mapping.

Theorem 3.5: *Every IFS contra continuous mapping is an IF$\pi g\gamma$* contra continuous mapping but not conversely.*
Proof: Suppose$f : (X_1, \tau) \to (X_2, \sigma)$is an IFS *contra* continuous mapping. SupposeB be an IFOS in X_2. Then by hypothesis $f^{-1}(B)$ is an IFSCS in X_1. As every IFSCS is an IF$\pi g\gamma$*CS, $f^{-1}(B)$ is an IF$\pi g\gamma$*CS in X_1. Hence f is an IF$\pi g\gamma$* contra continuous mapping.

Example 3.6: Suppose$X_1 = \{ a, b \}$, $X_2 = \{ u, v \}$ and $T_1 = \langle x_1, (0.4, 0.3), (0.5, 0.6) \rangle$and $T_2 = \langle x_2, (0.2, 0.2), (0.7, 0.7) \rangle$. Then $\tau = \{0_\sim, T_1, 1_\sim\}$ and $\sigma = \{0_\sim, T_2, 1_\sim\}$ are IFTs on X_1 and X_2 respectively. Define a mapping $f : (X_1, \tau) \to (X_2, \sigma)$ by f(a) = u and f(b) = v. The IFS $B = \langle x_2, (0.2, 0.2), (0.7, 0.7) \rangle$ is IFOS in X_2. Then $f^{-1}(B)$ is IF$\pi g\gamma$*CS in X_1 but not IFSCS in X_1. Then f is IF$\pi g\gamma$*contra continuous mapping but not an IFScontra continuous mapping.

Theorem 3.7: *Every IFP contra continuous mapping is an IF$\pi g\gamma$* contra continuous mapping but not conversely.*
Proof: Suppose$f : (X_1, \tau) \to (X_2, \sigma)$is an IFP *contra* continuous mapping. Suppose B is an IFOS in X_2. Then by hypothesis $f^{-1}(B)$ is an IFPCS in X_1. As every IFPCS is an IF$\pi g\gamma$*CS, $f^{-1}(B)$ is IF$\pi g\gamma$*CS in X_1. Hence f is an IF$\pi g\gamma$* contra continuous mapping.

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Example 3.8:*Suppose $X_1 = \{ a, b \}$, $X_2 = \{ u, v \}$ and $T_1 = \langle x_1, (0.2, 0.3), (0.5, 0.6) \rangle$, and $T_2 = \langle x_2, (0.3, 0.4), (0.6, 0.6) \rangle$. Then $\tau = \{0_\sim, T_1, 1_\sim\}$ and $\sigma = \{ 0_\sim, T_2, 1_\sim\}$ are IFTs on X_1 and X_2*respectively. Define a mapping $f : (X_1, \tau) \to (X_2, \sigma)$ by f(a) = u and f(b) = v. The IFS B = $\langle x_2, (0.3, 0.4), (0.6, 0.6) \rangle$ is IFOS in X_2. Then $f^{-1}(B)$ is IF$\pi g\gamma$*CS in X_1 but not IFPCS in X_1. Then *f* is IF$\pi g\gamma$* contra continuous mapping but not an IFP contra continuous mapping.

Theorem 3.9: *Every IFαcontra continuous mapping is an IF$\pi g\gamma$*contra continuous mapping but not conversely.*
Proof: Suppose$f : (X_1, \tau) \to (X_2, \sigma)$is an IFαcontra continuous mapping. Suppose Bis an IFOS in X_2. Then by hypothesis $f^{-1}(B)$ is an IFαCS in X_1. As every IFαCS is an IF$\pi g\gamma$*CS, $f^{-1}(B)$ is an IF$\pi g\gamma$*CS in X_1. Hence *f* is an IF$\pi g\gamma$*contra continuous mapping.

Example 3.10: Suppose $X_1 = \{ a, b \}$, $X_2 = \{ u, v \}$ and $T_1 = \langle x_1, (0.4, 0.2), (0.6, 0.7) \rangle$, $T_2 = \langle x_1, (0.7, 0.8), (0.2, 0.2) \rangle$ and $T_3 = \langle x_2, (0.5, 0.6), (0.4, 0.3) \rangle$. Then $\tau = \{0_\sim, T_1, T_2, 1_\sim\}$and $\sigma = \{ 0_\sim, T_3, 1_\sim\}$ are IFTs on X_1 and X_2 respectively. Define a mapping $f : (X_1, \tau) \to (X_2, \sigma)$ by f(a) = u and f(b) = v. The IFS B = $\langle x_2, (0.5, 0.6), (0.4, 0.3) \rangle$ is IFOS in X_2. Then $f^{-1}(B)$ is IF$\pi g\gamma$*CS in X_1 but not IFαCS in X_1. Then *f* is IFαG contra continuous mapping but not an IFαcontra continuous mapping.

Theorem 3.11: *Every IFγcontra continuous mapping is an IF$\pi g\gamma$*contra continuous mapping but not conversely.*
Proof: Suppose$f : (X_1, \tau) \to (X_2, \sigma)$is an IF$\gamma$contra continuous mapping. SupposeB is an IFOS in X_2. Then by hypothesis $f^{-1}(B)$ is an IFγCS in X_1. As every IFγCS is an IF$\pi g\gamma$*CS, $f^{-1}(B)$ is an IF$\pi g\gamma$*CS in X_1. Hence *f* is an IF$\pi g\gamma$*contra continuous mapping.

Example 3.12: Suppose $X_1 = \{ a, b \}$, $X_2 = \{ u, v \}$ and $T_1 = \langle x_1, (0.6, 0.6), (0.5, 0.4)\rangle$, $T_2 = \langle x_2, (0.2, 0.3), (0.8, 0.7) \rangle$ and $T_3 = \langle x_3, (0.6, 0.4), (0.4, 0.6) \rangle$. Then $\tau = \{0_\sim, T_1, T_2, 1_\sim\}$ and $\sigma = \{ 0_\sim, T_3, 1_\sim\}$ are IFTs on X_1 and X_2 respectively. Define a mapping $f : (X_1, \tau) \to (X_2, \sigma)$ by f(a) = u and f(b) = v. The IFSB = $\langle x_2, (0.6, 0.4), (0.4, 0.6) \rangle$ is IFOS in X_2. Then $f^{-1}(B)$ is IF$\pi g\gamma$*CS in X_1 but not IFγCS in X_1. Then *f* is IF$\pi g\gamma$*contra continuous mapping but not an IFγcontra continuous mapping.

Theorem 3.13: *Every IFG contra continuous mapping is an IF$\pi g\gamma$* contra continuous mapping but not conversely.*
Proof: Suppose$f : (X_1, \tau) \to (X_2, \sigma)$is an IFG contra continuous mapping. SupposeBis an IFOS in X_2. Then by hypothesis $f^{-1}(B)$ is an IFGCS in X_1. As every IFGCS is an IF$\pi g\gamma$*CS, $f^{-1}(B)$ is an IF$\pi g\gamma$*CS in X_1. Hence *f* is an IF$\pi g\gamma$* contra continuous mapping.

Example 3.14: Suppose $X_1 = \{ a, b \}$, $X_2 = \{ u, v \}$ and $T_1 = \langle x_1, (0.2, 0.8), (0.2, 0.0)\rangle$ and $T_2 = \langle x_2, (0.3, 0.8), (0.2, 0.1) \rangle$. Then $\tau = \{0_\sim, T_1, 1_\sim\}$ and $\sigma = \{ 0_\sim, T_2, 1_\sim\}$ are IFTs on X_1 and X_2 respectively. Define a mapping $f : (X, \tau) \to (Y, \sigma)$ by f(a) = u and f(b) = v. The IFS B = $\langle x_2, (0.3, 0.8), (0.2, 0.1) \rangle$ is IFOS in X_2. Then $f^{-1}(B)$ is IF$\pi g\gamma$*CS in X_1 but not IFGCS in X_1. Then *f* is IF$\pi g\gamma$* contra continuous mapping but not an IFG contra continuous mapping.

Theorem 3.15: *Every IFγ*G contra continuous mapping is an IF$\pi g\gamma$* contra continuous mapping.*
Proof: Suppose$f : (X_1, \tau) \to (X_2, \sigma)$is an IF$\gamma$*Gcontra continuous mapping. SupposeBis an IFOS in X_2. Then by hypothesis $f^{-1}(B)$ is an IFγ*GCS in X_1. As every IF$\gamma *$ GCS is an IF$\pi g\gamma$*CS, $f^{-1}(B)$ is an IF$\pi g\gamma$*CS in X_1. Hence *f* is an IF$\pi g\gamma$*contra continuous mapping.

Theorem 3.16: *Amapping $f : (X_1, \tau) \to (X_2, \sigma)$ is IF$\pi g\gamma$* contra continuous if and only if the inverse image of each IFCS in X_2 is an IF$\pi g\gamma$*OS in X_1.*
Proof: Suppose A is an IFCS in X_2. This implies A^c is IFOS in X_2. As *f* is IF$\pi g\gamma$* contra continuous, $f^{-1}(A^c)$ is IF$\pi g\gamma$*CS in X_1. As $f^{-1}(A^c) = (f^{-1}(A))^c$, $f^{-1}(A)$ is an IF$\pi g\gamma$* OS in X_1.

The relations between various types of intuitionistic fuzzy continuity are given in the following diagram. In this diagram 'cts.' means continuous.

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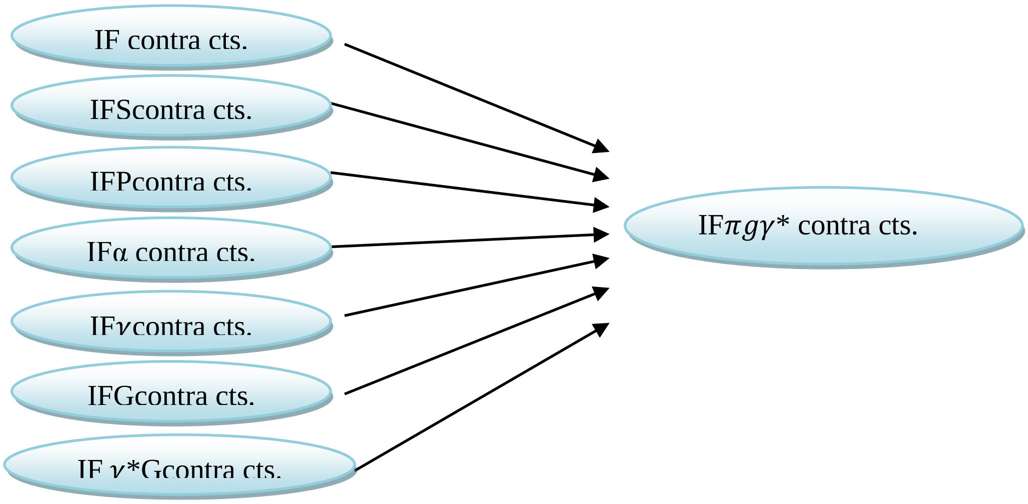

The reverse implications are not true in general.

Theorem 3.17: *Suppose* $f : (X_1, \tau) \to (X_2, \sigma)$ *is an IF*$\pi g\gamma$** contra continuous mapping, then f is an IF contra continuous mapping if* X_1 *is an IF*$\pi\gamma$**c*$T_{1/2}$ *space.*
Proof: Suppose B is an IFOS in X_2. Then $f^{-1}(B)$ is an IF$\pi g\gamma$*CS in X_1, by hypothesis. As X_1 is an IF$\pi\gamma$*c$T_{1/2}$ space, $f^{-1}(B)$ is an IFCS in X_1. Hence f is an IF contra continuous mapping.

Theorem 3.18: *Suppose* $f : (X_1, \tau) \to (X_2, \sigma)$ *is an IF*$\pi g\gamma$** contra continuous mapping then f is an IFG contra continuous mapping if* X_1 *is an IF*γ**g*$T_{1/2}$ *space.*
Proof: Suppose B is an IFOS in X_2. Then $f^{-1}(B)$ is IF$\pi g\gamma$*CS in X_1, by hypothesis. As X_1 is an IFγ*g$T_{1/2}$ space, $f^{-1}(B)$ is an IFGCS in X_1. Hence f is an IFG contra continuous mapping.

Theorem 3.19: *Suppose* $f : (X_1, \tau) \to (X_2, \sigma)$ *is an IF*$\pi g\gamma$** contra continuous mapping and* $g : (X_2, \sigma) \to (X_3, \delta)$ *is IF continuous, then* $g \circ f : (X_1, \tau) \to (X_3, \delta)$ *is an IF*$\pi g\gamma$** contra continuous mapping.*

Proof: Suppose B is an IFOS in Z. Then $g^{-1}(B)$ is an IFOS in X_2, by hypothesis. As f is an IF$\pi g\gamma$* contra continuous mapping, $f^{-1}(g^{-1}(B))$ is an IF$\pi g\gamma$*CS in X_1. Hence $g \circ f$ is an IF$\pi g\gamma$* contra continuous mapping.

Theorem 3.20: *Suppose* $f : (X_1, \tau) \to (X_2, \sigma)$ *is an IF*$\pi g\gamma$** continuous mapping and* $g : (X_2, \sigma) \to (X_3, \delta)$ *is IF contra continuous, then* $g \circ f : (X_1, \tau) \to (X_3, \delta)$ *is an IF*$\pi g\gamma$** contra continuous mapping.*

Proof: Suppose B is an IFOS in X_3. Then $g^{-1}(B)$ is an IFCS in X_3, by hypothesis. As f is an IF$\pi g\gamma$*continuous mapping, $f^{-1}(g^{-1}(B))$ is an IF$\pi g\gamma$*CS in X_1. Hence $g \circ f$ is an IF$\pi g\gamma$* contra continuous mapping.

Theorem 3.21: *Suppose* $f : (X_1, \tau) \to (X_2, \sigma)$ *is a mapping from an IFTS X into an IFTS* X_2*. Then the following conditions are equivalent if X is an IF*$\pi\gamma$**c*$T_{1/2}$*space.*
(i) f is an IF$\pi g\gamma$** contra continuous mapping*
(ii) If B is an IFOS in X_2 *then* $f^{-1}(B)$ *is an IF*$\pi g\gamma$**CS in* X_1
(iii) $f^{-1}(\mathrm{int}B) \supseteq cl(int(cl((f^{-1}(B)))$ *for every IFS B in* X_2.

Proof: (i) ⇒ (ii): is obviously true.
(ii) ⇒ (iii): Suppose B is any IFS in X_2. Then int(B) is an IFOS in X_2. Then $f^{-1}(\mathrm{int}(B))$ is an IF$\pi g\gamma$*CS in X_1. As X_1 is an IF$\pi\gamma$*c$T_{1/2}$ space, $f^{-1}(\mathrm{int}(B))$ is an IFCS in X_1. *Thus* $f^{-1}(\mathrm{int}\ B) = cl(f^{-1}(\mathrm{int}(B)) \supseteq cl(int(cl(f^{-1}(B))))$.
(iii) ⇒ (i): Suppose B is an IFCS in X_2. Then its complement B^c is an IFOS in X_2. By hypothesis $f^{-1}(\mathrm{int}\ (B^c)) \supseteq cl(int(cl(f^{-1}(B^c))))$. This implies $f^{-1}(B^c) \supseteq cl(int(cl(f^{-1}(B^c))))$. Hence $f^{-1}(B^c)$ is an IFαCS in X_1. As every IFαCS is an IF$\pi g\gamma$*CS, $f^{-1}(B^c)$ is an IF$\pi g\gamma$*CS in X_1. *Thus* $f^{-1}(B)$ is an IF$\pi g\gamma$*CS in X_1. Hence f is an IF$\pi g\gamma$* contra continuous mapping.

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