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Contra Weakly π Generalized Continuous Mapping in Intuitionistic Fuzzy Topologial Space

Dr. K.Vaithiyalingam

Assistant Professor, Department of Mathematics, Sri Vasavi College, Erode-638 316, Tamilnadu, India.

ABSTRACT
In this paper the concepts of intuitionistic fuzzy contra weakly π generalized continuous mapping in fuzzy topological spaces is introduced with numerical examples. Some of their basic properties and characterizations are investigated.

KEY WORDS
Intuitionistic Fuzzy (IF) topology, IF weakly π generalized closed set and open set, IF weakly π generalized continuous mappings and closed mapping, IF contra weakly π generalized continuous mapping.

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I. INTRODUCTION

In 1965, the concept of Fuzzy set (FS) theory and its applications are first proposed by Zadeh [19]. It provides a framework to encounter uncertainty, vagueness and partial truth. It is represented by introducing degree of membership for each member of the universe of discourse to a subset of it. In 1968, the concept of fuzzy topology has been introduced by Chang [2]. The concept of FS has generalized into intuitionistic fuzzy (IF) by Atanassov [1] in 1986. They are referred as a concept and its context. After that many research articles have been published in the study of examining and exploring, how far the basic concepts and theorems, defined in crisp sets and in fuzzy sets remain true in IF sets. In 1997, Coker [3] has initiated the concept of generalization of fuzzy topology into IF topology. In his research article, the apprehension of semi closed, α closed, semi pre-closed, weakly closed are introduced. Further its properties are derived.

In this paper, the concept of contra weakly π generalized continuous mapping in IF topological space is introduced. Suitable examples are given and investigated some of its characteristics. Numerical illustrations are also presented to substantiate the derived results on the characteristics of the newly defined IF topological space.

This paper is organized into four sections. In the first section, the historical development of the concepts is briefed. The basic definitions and results, needed for this work are listed in the second section. Section three discusses the Contra weakly π generalized continuous mapping in intuitionistic fuzzy topological space and suitable examples are given. Section four contains the conclusion remarks.

II. PRELIMINARIES

Definition 2.1: [1] Let X be a non-empty crisp set. An intuitionistic fuzzy (IF) set A, in X is defined as an object of the form
$A = \{< x, \mu_A(x), \nu_A(x) > | x \in X\}$,
where the functions $\mu_A(x) : X \to [0,1]$ and $\nu_A(x) : X \to [0,1]$ denote respectively the degree of membership (briefly μ_A) and the degree of non-membership (briefly ν_A) of each element $x \in X$ to the set A, for each $x \in X$ and $0 \leq \mu_A(x) + \nu_A(x) \leq 1$.
The collection of all IF sub-sets in X, is denoted by IFS(X).

Definition 2.2: [1] Let A and B be two different IFSs defined by,
$A = \{< x, \mu_A(x), \nu_A(x) > | x \in X\}$,
$B = \{< x, \mu_B(x), \nu_B(x) > | x \in X\}$ or briefly,
$A = < x, \mu_A, \nu_A >$ and $B = < x, \mu_B, \nu_B >$ respectively.

The operations $\wedge$ and $\vee$ on A and B are defined with respect to μ_A, μ_B, ν_A, and ν_B as follows:

i) $\mu_A \vee \mu_B = \max\{\mu_A, \mu_B\}$,
ii) $\mu_A \wedge \mu_B = \min\{\mu_A, \mu_B\}$,
iii) $\nu_A \vee \nu_B = \max\{\nu_A, \nu_B\}$, and
iv) $\nu_A \wedge \nu_B = \min\{\nu_A, \nu_B\}$.

Then,
i) $A \subseteq B$, if and only if, $\mu_A \leq \mu_B$ and $\nu_A \geq \nu_B$ for all $x \in X$, similarly $A \supseteq B$ can be defined.
ii) $A = B$, if and only if, both $A \subseteq B$ and $B \subseteq A$ are valid.
iii) $A^c = \{< x, \mu'_A, \nu'_A > | x \in X\}$, where $\mu'_A = \nu_A$ and $\nu'_A = \mu_A$.
iv) $A \cap B = \{< x, \mu_A \wedge \mu_B, \nu_A \vee \nu_B > | x \in X\}$, and
v) $A \cup B = \{< x, \mu_A \vee \mu_B, \nu_A \wedge \nu_B > | x \in X\}$.

The intuitionistic fuzzy sets $0_\sim$ and $1_\sim$ are defined respectively as, $0_\sim = \{< x, 0, 1 > | x \in X\}$ and $1_\sim = \{< x, 1, 0 > | x \in X\}$. The sets $0_\sim$ and $1_\sim$ are known as the empty IF set and the whole IF set of X respectively.

Definition 2.3: [3] An intuitionistic fuzzy topology (IFT) is a family τ of IFS defined on X, satisfying the following axioms:

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

Then the pair (X, τ) is called an intuitionistic fuzzy topological space (IFTS) and any IFS in τ are known as an intuitionistic fuzzy open set (IFOS) in X.

If, A is an IFOS, in an IFTS (X, τ), then its complement A^c is called an intuitionistic fuzzy closed set (IFCS) in X.

Definition 2.4: [3] Let (X, τ) be an IFTS and $A = < x, \mu_A, \nu_A >$ be an IFS in X. Then the intuitionistic fuzzy closure and an intuitionistic fuzzy interior are defined by ,

$$cl(A) = \cap\{G \mid G \text{ is an IFCS in } X \text{ and } A \subseteq G\}, \text{ and}$$
$$int(A) = \cup\{K \mid K \text{ is an IFOS in } X \text{ and } K \subseteq A\}.$$

Note that for any IFS, A in X, $cl(A^c) = \left(int(A)\right)^c$ and $int(A^c) = \left(cl(A)\right)^c$.

Definition 2.5: [3] An IFS, $A = < x, \mu_A, \nu_A >$ in an IFTS(X, τ) is said to be an,

i) intuitionistic fuzzy closed set (IFCS) in $X \Leftrightarrow cl(A) = A$, and

ii) intuitionistic fuzzy open set (IFOS) in $X \Leftrightarrow int(A) = A$.

Definition 2.6: [15] A subset A of a space (X, τ) is called,
i) regular open, if, $A = int\left(cl(A)\right)$, and
ii) π open, if, A is the union of regular open sets, symbolically A is an IFπOS in X.

Definition 2.7: [5] An IFS, $A = < x, \mu_A, \nu_A >$ in an IFTS(X, τ) is said to be an,
i) intuitionistic fuzzy semi-closed set (IFSCS) if $int\left(cl(A)\right) \subseteq A$, and
ii) intuitionistic fuzzy semi-open set (IFSOS) if $A \subseteq cl\left(int(A)\right)$.

Definition 2.8: [18] Let A be an IFS of an IFTS (X, τ). Then the semi-closure of A (simply $scl(A)$) and semi-interior of A (simply $sint(A)$) are defined as,

$$i)\ scl(A) = \cap\{G \mid G \text{ is an IFSCS in } X \text{ and } A \subseteq G\},$$
$$ii)\ sint(A) = \cup\{K \mid K \text{ is an IFSOS in } X \text{ and } K \subseteq A\}.$$

Result 2.1: [16] Let A be an IFS in (X,τ), then
i) $scl(A) = A \cup int\big(cl(A)\big)$, and
ii) $sint(A) = A \cap cl\big(int(A)\big)$.

Definition 2.9: [5] An IFS, $A = < x, \mu_A, \nu_A >$ in an IFTS(X,τ) is said to be an,
i) intuitionistic fuzzy α closed set (IFαCS), if, $cl\Big(int\big(cl(A)\big)\Big) \subseteq A$, and
ii) intuitionistic fuzzy α open set (IFαOS), if, $A \subseteq int\Big(cl\big(int(A)\big)\Big)$.

Definition 2.10: [11] Let $A = < x, \mu_A, \nu_A >$ be an IFS of an IFTS(X,τ). Then, the α closure of A ($\alpha\ cl(A)$) and α interior of A $\big(\alpha\ int(A)\big)$ are defined as,
$\alpha\ cl(A) = \cap\ \{G \mid G \text{ is an } IF\alpha CS \text{ in } X \text{ and } A \subseteq G\}$,
and
$\alpha\ int\ (A) = \cup\ \{K \mid K \text{ is an } IF\alpha OS \text{ in } X \text{ and } K \subseteq A\}$.

Result 2.2: [12] Let A be an IFS in (X,τ), then,
i) $\alpha\ cl(A) = A \cup cl\Big(int\big(cl(A)\big)\Big)$, and
ii) $\alpha\ int(A) = A \cap int\Big(cl\big(int(A)\big)\Big)$.

Definition 2.11: An IFS, $A = < x, \mu_A, \nu_A >$ in an IFTS$(X,\tau)$is said to be an
i) intuitionistic fuzzy pre-closed set [5] (IFPCS) if, $cl\big(int(A)\big) \subseteq A$,
ii) intuitionistic fuzzy regular closed set [5] (IFRCS) if, $cl\big(int(A)\big) = A$,
iii)intuitionistic fuzzy generalized closed set [17] (IFGCS) if,$cl(A) \subseteq U$ whenever $A \subseteq U$, U is an IFOS in X,
iv)intuitionistic fuzzy generalized semi closed set [14] (IFGSCS) if, $scl(A) \subseteq U$ whenever $A \subseteq U$, U is an IFOS in X,
v)intuitionistic fuzzy α generalized closed set [12] (IFαGCS) if, $\alpha\ cl(A) \subseteq U$ whenever $A \subseteq U$,U is an IFOS in X.

Definition 2.12: [6] An IFS, A is said to be an intuitionistic fuzzy weakly π generalized closed set (IFWπGCS) in (X,τ) if, $cl\big(int(A)\big) \subseteq U$ whenever $A \subseteq U$ and U is an IFπOS in X.

The family of all IFWπGCS of an IFTS (X,τ) is denoted by IFWπGCS(X).

Result 2.3:[6] Every IFCS, IFαCS, IFGCS, IFRCS, IFPCS, IFαGCS are IFWπGCS but the converse need not be true.

Definition 2.13: [6] An IFS, A is said to be an intuitionistic fuzzy weakly π generalized open set (IFWπGOS) in (X,τ) if, the complement A^c is an IFWπGOS in X.

The family of all IFWπGOS of an IFTS (X,τ) is denoted by IFWπGOS (X).

Definition 2.14: [5] Let f be a mapping defined on an IFTS (X,τ) into IFTS (Y,σ). Then f is said intuitionistic fuzzy continuous (IF cts) if, $f^{-1}(B) \in$ IFOS (X) for every $B \in \sigma$.

Definition 2.15:[7] A mapping$f\colon (X,\tau) \to (Y,\sigma)$ is called an intuitionistic fuzzy weakly π generalized continuous mapping (IFWπG cts) if, $f^{-1}(B)$ is an IFWπGCS in (X,τ) for every IFCS, $B$of (Y,σ).

Definition 2.16: Let f be a mapping from an IFTS (X,τ) into IFTS(Y,σ). Then f is said to be
i) intuitionistic fuzzy contra [4] continuous mapping if, $f^{-1}(B) \in$ IFCS (X), for every $B \in \sigma$,
ii)intuitionistic fuzzy contra α continuous mapping [4] (If contra α cts) if, $f^{-1}(B) \in$ IFαC (X), for every $B \in \sigma$,
iii) intuitionistic fuzzy contra pre-continuous mapping [4] if, $f^{-1}(B) \in$ IFPC (X), for every $B \in \sigma$,
iv) intuitionistic fuzzy contra α generalized continuous mapping [13] if, $f^{-1}(B) \in$ IFαGC (X), for every $B \in \sigma$,
v) intuitionistic fuzzy contra semi-continuous mapping [4] if, $f^{-1}(B) \in$ IFSC (X), for every $B \in \sigma$,

Definition 2.17: [8] Let (X,τ) and (Y,σ) be two IFTS. A mapping $f:(X,\tau) \to (Y,\sigma)$ is called an intuitionistic fuzzy weakly π generalized closed mapping (IFWπGCM) if, $f(A)$ is an IFWπGCS in Y, for every IFCS, A in X. In other words, every IFCS in X are mapped into IFWπGCS in Y.

Definition 2.18: [9] Let (X,τ) and (Y,σ) be two IFTS. A mapping $f:(X,\tau) \to (Y,\sigma)$ is called an intuitionistic fuzzy completely weakly π generalized continuous mapping (IF completely WπG cts) if, $f^{-1}(B)$ is an IFRCS in (X,τ) for every IFWπGCS, B of (Y,τ).

Definition 2.19: [10] Let (X,τ) and (Y,σ) be two IFTS. A bijection mapping $f:(X,\tau) \to (Y,\sigma)$ is called an intuitionistic fuzzy weakly π generalized (IFWπG) homeomorphism if, both the functions, f and f^{-1} are IFWπG continuous mappings.

Definition 2.20: [6] An IFTS (X,τ) is called an intuitionistic fuzzy $_{w\pi g}T_{1/2}$ (IF $_{w\pi}T_{1/2}$) space if, every IFWπGCS in X is an IFCS in X.

Definition 2.21: [6] An IFTS (X,τ) is called an intuitionistic fuzzy $_{w\pi g}T_q$ (IF $_{w\pi g}T_q$) space, (0 < q < 1) if, every IFWπGCS in X is an IFPCS in X.

III. Intuitionistic Fuzzy Contra Weakly π Generalized Continuous Mapping

The main objective of this section is to study the Intuitionistic Fuzzy contra weakly π generalized continuous mapping on a topological spaces, in this connection some of its properties are obtained.

Definition 3.1: A mapping $f:(X,\tau) \to (Y,\sigma)$ is called an intuitionistic fuzzy contra weakly π generalized continuous mapping (IFcontraWπG cts) if, $f^{-1}(B)$ is an IFWπGCS in (X,τ) for every IFOS, B of (Y,σ).

Example 3.1: Let $X = \{a,b\}$, $Y = \{u,v\}$ and $G_1 = < x,(0.3,0.2),(0.6,0.7) >$, $G_2 = < y,(0.5,0.6),(0.4,0.3) >$.
Then $\tau = \{0_\sim, G_1, 1_\sim\}$ and $\sigma = \{0_\sim, G_2, 1_\sim\}$ are IFTs on X and Y respectively. Define a mapping $f:(X,\tau) \to (Y,\sigma)$ by $f(a) = u$ and $f(b) = v$. Then f is an IFcontraWπG continuous mapping.

Proposition 3.1: Every IF contra continuous mapping is an IFcontraWπG continuous mapping but not conversely.

Proof: Let $f:(X,\tau) \to (Y,\sigma)$ be an IF contra continuous mapping. Let B be an IFOS in Y. Since f is IF contra continuous mapping, $f^{-1}(B)$ is an IFCS in X. Since every IFCS is an IFWπGCS, $f^{-1}(B)$ is an IFWπGCS in X. Therefore f is an IFcontraWπG continuous mapping.

Example 3.2: Let $X = \{a,b\}$, $Y = \{u,v\}$ and $G_1 = < x,(0.2,0.4),(0.8,0.6) >$, $G_2 = < y,(0.2,0.1),(0.8,0.7) >$.
Then $\tau = \{0_\sim, G_1, 1_\sim\}$ and $\sigma = \{0_\sim, G_2, 1_\sim\}$ are IFTs on X and Y respectively. Define a mapping $f:(X,\tau) \to (Y,\sigma)$ by $f(a) = u$ and $f(b) = v$. The IFS, $B = < y,(0.2,0.1),(0.8,0.7) >$ is IFCS in Y. Then $f^{-1}(B)$ is IFWπGCS in X, but not IFOS in X. Therefore f is an IFcontraWπG continuous mapping but not an IF contra continuous mapping.

Proposition 3.2: Every IF contra α continuous mapping is an IFcontraWπG continuous mapping but not conversely.

Proof: Let $f:(X,\tau) \to (Y,\sigma)$ be an IF contra α continuous mapping. Let B be an IFOS in Y. Then by definition $f^{-1}(B)$ is an IFαCS in X. Since every IFαCS is an IFWπGCS, $f^{-1}(B)$ is an IFWπGCS in X. Thus f is an IFcontraWπG continuous mapping.

Example 3.3: Let $X = \{a, b\},\ Y = \{u, v\}$ and $G_1 = < x, (0.5, 0.4), (0.5, 0.6) >$, $G_2 = < y, (0.3, 0.2), (0.6, 0.8) >$.
Then $\tau = \{ 0_\sim, G_1, 1_\sim \}$ and $\sigma = \{ 0_\sim, G_2, 1_\sim \}$ are IFTs on X and Y respectively. Define a mapping $f: (X, \tau) \to (Y, \sigma)$ by $f(a) = u$ and $f(b) = v$. The IFS, $B = < y, (0.3, 0.2), (0.6, 0.8) >$ is IFOS in Y. Then $f^{-1}(B)$ is IFWπGCS in X, but not IFαCS in X. Then f is an IFcontraWπG continuous mapping but not an IFα continuous mapping.

Proposition 3.3: Every IF pre-continuous mapping is an IFcontraWπG continuous mapping but not conversely.

Proof: Let $f: (X, \tau) \to (Y, \sigma)$ be an IF pre-continuous mapping. Let B be an IFOS in Y. Then $f^{-1}(B)$ is an IFPCS in X. Since every IFPCS is an IFWπGCS, $f^{-1}(B)$ is an IFWπGCS in X. Therefore f is an IFcontraWπG continuous mapping.

Example 3.4: Let $X = \{a, b\},\ Y = \{u, v\}$ and $G_1 = < x, (0.4, 0.3), (0.6, 0.7) >$, $G_2 = < y, (0.6, 0.4), (0.4, 0.4) >$.
Then $\tau = \{ 0_\sim, G_1, 1_\sim \}$ and $\sigma = \{ 0_\sim, G_2, 1_\sim \}$ are IFTs on X and Y respectively. Define a mapping $f: (X, \tau) \to (Y, \sigma)$ by $f(a) = u$ and $f(b) = v$. The IFS, $B = < y, (0.4, 0.4), (0.6, 0.4) >$ is IFOS in Y. Then $f^{-1}(B)$ is IFWπGCS in X, but not IFPCS in X. Therefore f is IFcontraWπG continuous mapping but not an IF pre-continuous mapping.

Proposition 3.4: Every IF contra α generalized continuous mapping is an IFWπG continuous mapping but not conversely.

Proof: Let $f: (X, \tau) \to (Y, \sigma)$ be an IF contra α generalized continuous mapping. Let B be an IFOS in Y. Then by definition, $f^{-1}(B)$ is an IFαGCS in X. Since every IFαGCS is an IFWπGCS, $f^{-1}(B)$ is an IFWπGCS in X. So, f is an IFcontraWπG continuous mapping.

Example 3.5: Let $X = \{a, b\},\ Y = \{u, v\}$ and $G_1 = < x, (0.4, 0.6), (0.2, 0.2) >$, $G_2 = < y, (0.3, 0.2), (0.4, 0.3) >$.
Then $\tau = \{ 0_\sim, G_1, 1_\sim \}$ and $\sigma = \{ 0_\sim, G_2, 1_\sim \}$ are IFTs on X and Y respectively. Define a mapping $f: (X, \tau) \to (Y, \sigma)$ by $f(a) = u$ and $f(b) = v$. The IFS, $B = < y, (0.3, 0.2), (0.4, 0.3) >$ is IFOS in Y. Then $f^{-1}(B)$ is IFWπGCS in X, but not IFαGCS in X. Therefore f is IFcontraWπG continuous mapping but not an IF contra α generalized continuous mapping.

Remark 3.1: IF contra semi-continuous mapping and IFcontraWπG continuous mapping are independent to each other.

Example 3.6: Let $X = \{a, b\},\ Y = \{u, v\}$ and $G_1 = < x, (0.3, 0.4), (0.7, 0.6) >$, $G_2 = < y, (0.3, 0.4), (0.7, 0.6) >$.
Then $\tau = \{ 0_\sim, G_1, 1_\sim \}$ and $\sigma = \{ 0_\sim, G_2, 1_\sim \}$ are IFTs on X and Y respectively. Define a mapping $f: (X, \tau) \to (Y, \sigma)$ by $f(a) = u$ and $f(b) = v$. Then f is IF contra semi-continuous mapping but not an IFcontraWπG continuous mapping, since $B = < y, (0.3, 0.4), (0.7, 0.6) >$ is an IFSOS in Y, but $f^{-1}(B) = < x, (0.3, 0.4), (0.7, 0.6) >$ is not an IFWπGCS in X.

Example 3.7: Let $X = \{a, b\},\ Y = \{u, v\}$ and $G_1 = < x, (0.9, 0.7), (0.1, 0.2) >$, $G_2 = < y, (0.3, 0.4), (0.7, 0.6) >$.
Then $\tau = \{ 0_\sim, G_1, 1_\sim \}$ and $\sigma = \{ 0_\sim, G_2, 1_\sim \}$ are IFTs on X and Y respectively. Define a mapping $f: (X, \tau) \to (Y, \sigma)$ by $f(a) = u$ and $f(b) = v$. Then f is IFcontraWπG continuous mapping, but not an IF contra semi-continuous mapping, since $B = < y, (0.7, 0.6), (0.3, 0.4) >$ is an IFWπGCS in Y, but $f^{-1}(B) = < x, (0.7, 0.6), (0.3, 0.4) >$ is not an IFSCS in X.

Remark 3.2: IF contra generalized semi-continuous mapping and IFcontraWπG continuous mapping are independent to each other.

Example 3.8: Let $X = \{a, b\},\ Y = \{u, v\}$ and $G_1 = < x, (0.2, 0.3), (0.5, 0.5) >$, $G_2 = < y, (0.5, 0.5), (0.2, 0.3) >$.
Then $\tau =\{\ 0_\sim, G_1, 1_\sim \}$ and $\sigma = \{\ 0_\sim, G_2, 1_\sim \}$ are IFTs on X and Y respectively. Define a mapping $f: (X, \tau) \to (Y, \sigma)$ by $f(a) = u$ and $f(b) = v$. Then f is IF contra generalized semi- continuous mapping, but not an IFcontraWπG continuous mapping, since $B = < y, (0.2, 0.3), (0.5, 0.5) >$ is an IFGSCS in Y, but $f^{-1}(B) =< x, (0.2, 0.3), (0.5, 0.5) >$ is not an IFWπGCS in X.

Example 3.9: Let $X = \{a, b\},\ Y = \{u, v\}$ and $G_1 = < x, (0.5, 0.6), (0.2, 0.2) >$, $G_2 = < y, (0.6, 0.6), (0.3, 0.2) >$.
Then $\tau =\{\ 0_\sim, G_1, 1_\sim \}$ and $\sigma = \{\ 0_\sim, G_2, 1_\sim \}$ are IFTs on X and Y respectively. Define a mapping $f: (X, \tau) \to (Y, \sigma)$ by $f(a) = u$ and $f(b) = v$. Then f is IFcontraWπG continuous mapping, but not an IF contra generalized semi-continuous mapping, since $B = < y, (0.3, 0.2), (0.6, 0.6) >$ is an IFWπGCS in Y but $f^{-1}(B) =< x, (0.3, 0.2), (0.6, 0.6) >$ is not an IFGSCS in X.

Remark 3.3:The derived relationship among the terms can be schematically presented as follows.

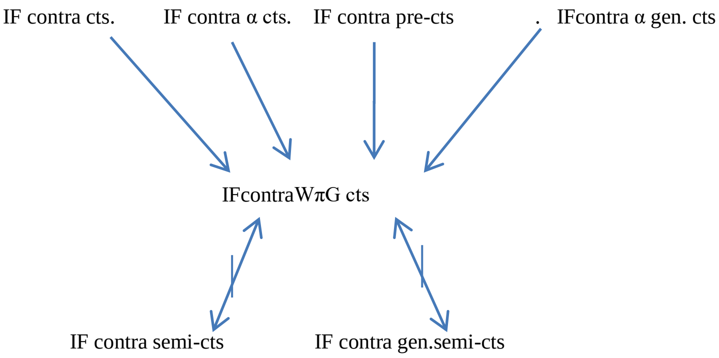

Fig.3.1 Relationships between the contra weakly π generalized continuous mapping, and the other existing contra continuous mapping on intuitionistic fuzzy sets.

IV. CONCLUSION

In this paper, a special type of continuous mapping, namely contra weakly π generalized continuous mapping in Intuitionistic Fuzzy Topological Spaces is introduced. Some of the basic properties of contra weakly π generalized continuous mapping in intuitionistic fuzzy toplological spaces are derived. Also the relationship among the intuitionistic fuzzy contra weakly π generalized continuous mapping and other existing intuitionistic fuzzy contra continuous mapping are studied. By means of suitable numerical examples, it is established that the converse of the propositions describing the properties, need not be true.

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