International Academic Institute for Science and Technology

International Academic Journal of Science and Engineering
Vol.10, No.2, 2023, pp.164-168.

ISSN 2454-3896

International Academic Journal of Science and Engineering

www.iaiest.com

Intuitionistic Fuzzy Semi-$\mathcal{g}$precompactness

Afkar Kareem Manhi [a]

[a] *Ministry of Education Department, Education of Thi-Qar, Iraq. E-mail: Afkarkareem9@gmail.com*

Abstract

In this research, we present the concepts of intuitionistic fuzzy semi-$\mathcal{g}$preopen set explained by gradation of openness. We defined intuitionistic fuzzy semi-$\mathcal{g}$compact, also we present almost semi-$\mathcal{g}$compact.

Keyword: Intuitionistic Fuzzy Semi-$\mathcal{g}$preopen, Intuitionistic Fuzzy Semi-$\mathcal{g}$precompact, Intuitionistic Fuzzy Almost Semi-$\mathcal{g}$precompact, Intuitionistic Nearly Fuzzy Semi-$\mathcal{g}$pre compact.

DOI:10.71086/IAJSE/V10I2/IAJSE1020
Received: 28 March 2023/Revised: 29 April 2023/Accepted: 23 May 2023/Published: 29 June 2023

Introduction

Classically concept of fuzzy set has appeared around 1965 by L. Zadeh [1].

This idea of a fuzzy sets allows a convenient starting point for constructing a conceptual framework that parallels in many respects the one used in the case of ordinary sets [11], but is more general than the latter, and may prove to have a much broader scope of application, particularly in the areas of pattern classification and information processing [2][3].

But the development of this concept into fuzzy topology, and put fuzzy subsets of set X in a collection called T, this definition was presented by Change [4].

Chattopadyay [5] redefined the concept of fuzzy topology by the gradation of openness, the gradation of openness of fuzzy sets obtained by a pair of descending families of topologies [6]. while the concepts of fuzzy interior and fuzzy closure were presented by M. Demirci [7].

The order pair (G,G^*) of mapping gives us many works to do, open operator and closure operator [1], we have generalized some set like intuitionistic fuzzy semi-$\mathcal{g}$preopen set. Also, we have had new concept that intuitionistic fuzzy semi-$\mathcal{g}$precompact and intuitionistic fuzzy almost semi-$\mathcal{g}$precompact.

Definition

An intuitionistic gradation of openness on set X an order pair $(\mathcal{g}, \mathcal{g}^*)$ is a mapping from I^x to I such that I=[0,1] satisfies [8]:

1) $\mathcal{g}(A) + \mathcal{g}^*(A) \leq 1, \forall A \in I^x$
2) $\mathcal{g}(\underline{0}) = \mathcal{g}(\underline{1}) = 1, \mathcal{g}^*(\underline{0}) = \mathcal{g}^*(\underline{1}) = 0$
3) $\mathcal{g}(A_1 \wedge A_2) \geq \mathcal{g}(A_1) \wedge \mathcal{g}(A_2)$ and $\mathcal{g}^*(A_1 \wedge A_2) \leq \mathcal{g}^*(A_1) \vee \mathcal{g}^*(A_2), \forall A_i \in I^X$
4) $\mathcal{g}(\vee_{i\in\Gamma} A_i) \geq \wedge_{i\in\Gamma} \mathcal{g}(A_i)$ and $\mathcal{g}^*(\vee_{i\in\Gamma} A_i) \leq \vee_{i\in\Gamma} \mathcal{g}^*(A_i)$, $\forall A_i \in I^X$

so, the triple (X, $\mathcal{g}, \mathcal{g}^*$) is called an intuitionistic fuzzy topological space as gradation of openness and gradation of non-openness, respectively

Example

Let X= {a, c}, define subsets $\sigma_1, \sigma_2 \in I^X$ as follows:

$$\sigma_1(a) = 0.3 \qquad \sigma_1(c) = 0.6$$
$$\sigma_2(a) = 0.2 \qquad \sigma_2(c) = 0.5$$
$$\mathcal{g}(\delta) = \begin{cases} 1 & if\ \delta = \underline{0}, \underline{1} \\ \frac{3}{2} & if\ \delta = \sigma_1 \\ 0 & otherwise \end{cases} \qquad \mathcal{g}^* = \begin{cases} 0 & if\ \delta = \underline{0}, \underline{1} \\ \frac{1}{2} & if\ \delta = \sigma_1 \\ 1 & otherwise \end{cases}$$

then $(\mathcal{g}, \mathcal{g}^*)$ is intuitionistic fuzzy gradation of openness

Definition {1] (Closure Operator)

let (x,$\mathcal{g}, \mathcal{g}^*$) be an intuitionistic fuzzy topological space,

1) define an operator $\mathbb{C}_{\mathcal{g},\mathcal{g}^*}: I^X \times I_0 \times I_1 \to I^X$ by:
   $\mathbb{C}_{\mathcal{g},\mathcal{g}^*}(\gamma, r, s) = \wedge \{\sigma \in I^X : \gamma \leq \sigma, \mathcal{g}(\underline{1} - \sigma) \geq r, \mathcal{g}^*(\underline{1} - \sigma) \leq s\}$

This operator Fulfills the following conditions:

a. $\mathbb{C}_{\mathcal{g},\mathcal{g}^*}(\underline{0}, r, s) = \underline{0}$
b. $\gamma \leq \mathbb{C}_{\mathcal{g},\mathcal{g}^*}(\gamma, r, s)$
c. $\mathbb{C}_{\mathcal{g},\mathcal{g}^*}(\gamma, r, s) \vee \mathbb{C}_{\mathcal{g},\mathcal{g}^*}(\sigma, r, s) = \mathbb{C}_{\mathcal{g},\mathcal{g}^*}(\gamma \vee \sigma, r, s)$
d. $\mathbb{C}_{\mathcal{g},\mathcal{g}^*}(\gamma, r, s) \leq \mathbb{C}_{\mathcal{g},\mathcal{g}^*}(\gamma, r_1, s_1)$ $if\ r \leq r_1, s \leq s_1$
e. $\mathbb{C}_{\mathcal{g},\mathcal{g}^*}(\mathbb{C}_{\mathcal{g},\mathcal{g}^*}(\gamma, r, s), r, s) = \mathbb{C}_{\mathcal{g},\mathcal{g}^*}(\gamma, r, s)$

2) Define an operator $I_{\mathcal{g},\mathcal{g}^*}: I^X \times I_0 \times I_1 \to I^X$ by
   $I_{\mathcal{g},\mathcal{g}^*}(\gamma, r, s) = \vee \{\sigma \in I^X : \gamma \geq \sigma, \mathcal{g}(\sigma) \geq r, \mathcal{g}^*(\sigma) \leq s\}$

The operator $I_{\mathcal{g},\mathcal{g}^*}(\sigma, r, s)$ satisfies:

a. $I_{\mathcal{g},\mathcal{g}^*}(\underline{1} - \gamma, r, s) = \underline{1} - \mathbb{C}_{\mathcal{g},\mathcal{g}^*}(\gamma, r, s)$

and $\mathbb{C}_{\mathcal{g},\mathcal{g}^*}(\underline{1}-\gamma,r,s)=\underline{1}-I_{\mathcal{g},\mathcal{g}^*}(\gamma,r,s)$

b. $I_{\mathcal{g},\mathcal{g}^*}(\underline{1},r,s)=\underline{1}$
c. $\gamma \geq I_{\mathcal{g},\mathcal{g}^*}(\gamma,r,s)$
d. $I_{\mathcal{g},\mathcal{g}^*}(\gamma,r,s)\wedge I_{\mathcal{g},\mathcal{g}^*}(\sigma,r,s)=I_{\mathcal{g},\mathcal{g}^*}(\gamma\wedge\sigma,r,s)$
e. $I_{\mathcal{g},\mathcal{g}^*}(\gamma,r,s)\geq I_{\mathcal{g}.\mathcal{g}^*}(\gamma,r_1,s_1) if\ r\leq r_1\ and\ s\geq s_1$
f. $I_{\mathcal{g},\mathcal{g}^*}\left(I_{\mathcal{g},\mathcal{g}^*}(\gamma,r,s),r,s\right)=I_{\mathcal{g},\mathcal{g}^*}(\gamma,r,s)$

Definition: [9]

Let (X, $\mathcal{g},\mathcal{g}^*$) be If topological space, we call

1) A fuzzy set $\gamma\in I^X$ is said to be an If semi-$\mathcal{g}$preopen set if and only if, there exist $r\in I_0 s\in I_1$ such that $\gamma\leq\mathbb{C}_{\mathcal{g},\mathcal{g}^*}\left(I_{\mathcal{g},\mathcal{g}^*}\left(\mathbb{C}_{\mathcal{g},\mathcal{g}^*}(\gamma,r,s)\gamma,r,s\right)\gamma,r,s\right)$
2) A fuzzy set $\gamma\epsilon I^X$ is said to be an If semi-$\mathcal{g}$preclosed set if and only if, there exist $r\in I_0 s\in I_1$ such that $I_{\mathcal{g},\mathcal{g}^*}\left(\mathbb{C}_{\mathcal{g},\mathcal{g}^*}\left(I_{\mathcal{g},\mathcal{g}^*}(\gamma,r,s)\gamma,r,s\right)\gamma,r,s\right)\leq\gamma$

Definition: let (X,$\mathcal{g},\mathcal{g}^*$) and (Y,$\vartheta,\vartheta^*$) be two If topological spaces and $F:X\to Y$ be a maping, then F is called:

1) An If semi-$\mathcal{g}$preirresolute if and only if $F^{-1}(\sigma)$ is an If semi-$\mathcal{g}$preopen set in X, for each If semi-$\mathcal{g}$preopen σ in Y.
2) An If semi-$\mathcal{g}$preirresoiute open if and only if F(σ) is an If semi-$\mathcal{g}$preopen set in Y, for each If semi-$\mathcal{g}$preopen σ in X**.**

Definition [10]: let (x, $\mathcal{g}$, $\mathcal{g}^*$) be If topology space, then

1) The If semi-$\mathcal{g}$preinterior of γ ,denoted by SP$I_{\mathcal{g},\mathcal{g}^*}(\gamma)$ is define:
SP$I_{\mathcal{g},\mathcal{g}^*}(\gamma)=\vee\{\vartheta\epsilon I^X:\vartheta\leq\gamma,\vartheta\ is\ an\ If\ semi-\mathcal{g}preopen\ set\}$
2) The If semi-$\mathcal{g}$preclosure of γ , denoted by:
$SPC_{\mathcal{g},\mathcal{g}^*}(\gamma)$ is defined by:
$SPC_{\mathcal{g},\mathcal{g}^*}(\gamma)=\wedge\{\vartheta\in I^X:\vartheta\geq\gamma,\vartheta\ is\ an\ If\ semi-\mathcal{g}preclosed\}$

Intuitionistic Fuzzy Semi-$\mathcal{g}$precompact

Definition: A collection $\{\sigma_i, i\epsilon I, \mathcal{g}(\sigma_{I)}\geq r,\mathcal{g}^*(\sigma_i)\leq s\}$ of If semi-$\mathcal{g}$preopen of If topological space (X,$\mathcal{g},\mathcal{g}^*$) is said to be If semi-$\mathcal{g}$preopen cover of a set A if $A\leq\vee\ \sigma_i, i\epsilon I, \mathcal{g}(\sigma_{I)}\geq r,\mathcal{g}^*(\sigma_i)\leq s\}$

Definition: A subset A of If topological space (X, $\mathcal{g},\mathcal{g}^*$) is said to be If semi-$\mathcal{g}$precompact if every collection$\{\sigma_i, i\epsilon I, \mathcal{g}(\sigma_{I)}\geq r,\mathcal{g}^*(\sigma_i)\leq s\}$

Of If semi-$\mathcal{g}$preopen set of X such that

$$A\leq\vee\{\boldsymbol{\sigma_i}, \boldsymbol{i\epsilon I}, \boldsymbol{\mathcal{g}(\sigma_{I)}\geq r,\mathcal{g}^*(\sigma_i)\leq s}\}$$, there is a finite subset I_0 of I such that

$$A\leq\vee\{\boldsymbol{\sigma_i}, \boldsymbol{i\epsilon I}, \boldsymbol{\mathcal{g}(\sigma_{I)}\geq r,\mathcal{g}^*(\sigma_i)\leq s}\}$$

Theorem: An If topological space (X, $\mathcal{g},\mathcal{g}^*$) is said to be If semi-$\mathcal{g}$precompact if for every family of If $\mathcal{g}$subset of X with the finite intersection property have a nonempty intersection.

Proof

Let X be If semi-$\mathcal{g}$precompact and let H= $\{\sigma_i, i\in I, \mathcal{g}(\sigma_i)\geq r,\mathcal{g}^*(\sigma_i)\leq s\}$

Denote any family of If **semi-**$\mathcal{g}$preclosed subset of X with the finite intersection property.

Suppose that $\wedge\{\sigma_i, i\in I, \mathcal{g}(\sigma_i)\geq r,\mathcal{g}^*(\sigma_i)\leq s\}=\underline{0}$

Then $\vee\{\sigma_i^C, i\in I, \mathcal{g}(\sigma_i)\geq r,\mathcal{g}^*(\sigma_i)\leq s\}=\underline{1}$

i.e $\vee\{\sigma_i^C, i\in I, \mathcal{g}(\sigma_i)\geq r,\mathcal{g}^*(\sigma_i)\leq s\}$ is If semi-$\mathcal{g}$preopen cover of X.

since X is If semi-$\mathcal{g}$precompact, there is implies that

$$\wedge\{\sigma_i, i\in I, \mathcal{g}(\sigma_i)\geq r,\mathcal{g}^*(\sigma_i)\leq s\}=\underline{0}$$

But that contradicts the assumption that H has a finite intersection property.

Hence $\wedge\{\sigma_i, i\in I, \mathcal{g}(\sigma_i)\geq r,\mathcal{g}^*(\sigma_i)\leq s\}\neq\underline{0}$.

Let $\beta = \{\sigma_i , i \in I , \mathcal{g}(\sigma_i) \geq r, \mathcal{g}^*(\sigma_i) \leq s\}$ denote an If semi-$\mathcal{g}$preopen cover of X and consider the family $\beta^/ = \{\sigma_i^c, i\epsilon I\}$ of If semi-$\mathcal{g}preclosed$ set.

Since β is a cover of X, $\wedge \{\sigma_i^c, i\epsilon I , \mathcal{g}(\sigma_i) \geq r, \mathcal{g}^*(\sigma_i) \leq s\} = \underline{0}$

Hence $\beta^/$ dose not have the finite intersection property, i.e. there are a finite number of If semi-$\mathcal{g}$preopen sets $\{\sigma_1, \sigma_2, \dots \sigma_n\}$ in β

Such that, $\wedge \{\sigma_i^c , i = 1,2, \dots n, , \mathcal{g}(\sigma_i) \geq r, \mathcal{g}^*(\sigma_i) \leq s\} \neq \underline{0}$

These implies that $\{\sigma_1 , \sigma_2 , \dots , \sigma_n\}$ is a finite sub cover of X in β ,

Hence X is If semi-$\mathcal{g}$precompact.

Theorem: let A and B be subsets of an If topological space (X, $\mathcal{g}, \mathcal{g}^*$)

If A is If semi-$\mathcal{g}$precompact and B is If semi-$\mathcal{g}$preclosed in X, then $A \wedge B$ is If semi-$\mathcal{g}$precompact.

Proof

Let $\beta = \{\sigma_i , i \in I , \mathcal{g}(\sigma_i) \geq r, \mathcal{g}^*(\sigma_i) \leq s\}$ be an If semi-$\mathcal{g}$preopen cover of X

Since B^C is If semi-$\mathcal{g}$preopen set in X

$(\vee \{ \sigma_i , i \in I, \mathcal{g}(\sigma_i) \geq r, \mathcal{g}^*(\sigma_i) \leq s\}) \vee B^C$ is If semi- $\mathcal{g}$preopen cover in X

Since A is If $\mathcal{g}$precompact in X, there is a finite subset I_0 of I

Such that $A \leq (\vee \{\sigma_i , i \in I_0 , \mathcal{g}(\sigma_i) \geq r, \mathcal{g}^*(\sigma_i) \leq s\}) \vee B^C$,

Therefore $A \wedge B \leq (\{\sigma_i , i \in I_0 , \mathcal{g}(\sigma_i) \geq r, \mathcal{g}^*(\sigma_i) \leq s\})$

Hence $A \wedge B$ is If semi-$\mathcal{g}$precompact.

Theorem: let (X,$\mathcal{g}, \mathcal{g}^*$) and (Y, ρ , ρ^*) be If topological spaces and $f: (X, \mathcal{g}, \mathcal{g}^*) \rightarrow (Y, \varphi , \varphi^*)$ be an If semi-$\mathcal{g}$preirresolute, surjective mapping, if (X, $\mathcal{g} , \mathcal{g}^*$) is If semi-$\mathcal{g}$precompact space then so is (Y, φ , φ^*).

Proof

Let $f: (X, \mathcal{g}, \mathcal{g}^*) \rightarrow (Y , \varphi , \varphi^*)$ be an If semi-$\mathcal{g}$preirresolute mapping of If semi-$\mathcal{g}$precompact space $(X, \mathcal{g}, \mathcal{g}^*)$.

Let $\{ \rho_i , i \in I, \mathcal{g}(\rho_i) \geq r, \mathcal{g}^*(\rho_i) \geq s\}$ be any If semi-$\mathcal{g}$preopen cover of (Y, φ , φ^*),

Then $\{f^{-1}(\sigma_i) , i \in I , \mathcal{g} (\sigma_i) \geq r, \mathcal{g}^*(\sigma_i) \leq s\}$ is collection of If semi-$\mathcal{g}$preopen sets which cover X.

By the hypothesis that X is If semi-$\mathcal{g}$precompact , so there exist a finite subset I_0 of I such that subfamily $\{f^{-1}(\sigma_i) , i \in I_0 , \mathcal{g} (\sigma_i) \geq r, \mathcal{g}^*(\sigma_i) \leq s\}$ of $\{f^{-1}(\sigma_i) , i \in I , \mathcal{g} (\sigma_i) \geq r, \mathcal{g}^*(\sigma_i) \leq s\}$ covers X.

It follows that $\{f^{-1}(\sigma_i) , i \in I_0 , \mathcal{g} (\sigma_i) \geq r, \mathcal{g}^*(\sigma_i) \leq s\}$ is a finite subfamily of $\{\sigma_i , i \in I , \mathcal{g} (\sigma_i) \geq r, \mathcal{g}^*(\sigma_i) \leq s\}$ which covers Y.

Hence Y is If semi-$\mathcal{g}$precompact.

Theorem: let (X, $\mathcal{g}, \mathcal{g}^*$) *and* (Y , φ, φ^*) be If topological spaces and $f: (X, \mathcal{g} , \mathcal{g}^*) \rightarrow (Y, \varphi, \varphi^*)$ be an If semi-$\mathcal{g}$preirreslute, if A is If semi-$\mathcal{g}$precompact in X then f(A) is a If semi-$\mathcal{g}$precompact in Y.

Proof

Let $\{A_i , i \in I, \mathcal{g}(A_i) \geq r, \mathcal{g}^*(A_I) \leq s\}$ be family of If semi-$\mathcal{g}$preopen cover of (Y, φ, φ^*) such that $f(A) \subseteq \vee_{i\in I} A_i$ so,

$A \subseteq f^{-1}\big(f(A)\big) \subseteq f^{-1}(\vee_{i\in I} A_i) = \vee_{i\in I} f^{-1}(A_i)$,

since f is If semi-$\mathcal{g}$preirreslute, $f^{-1}(A_i)$ is If semi-$\mathcal{g}$preopen cover of X and A is If semi-$\mathcal{g}$precompact in (X,$\mathcal{g} , \mathcal{g}^*$), so there exist afinite subset $I_0$of I such that $A \subseteq F^{-1}(A_I)$.

Hence $f(A) \subseteq f\big(\vee_{i\in I} f^{-1}(A_I)\big) = \vee_{i\in I} f(f^{-1}(A_I)) \subseteq \vee_{i\in I} A_i$

Thus $f(A)$ is If semi-$\mathcal{g}$pre compact in Y.

If Almost Semi-$\mathcal{g}$precompact

Definition :an If topology (X ,$\mathcal{g}$,$\mathcal{g}^*$) is called almost semi-$\mathcal{g}$precompact iff every family $(A_i)_{i\epsilon\Gamma} in \{A \in I^X: \mathcal{g}(A) > r, \mathcal{g}^*(A) < s\}$ covering of X , we have $\vee_{i\in\Gamma} SPC_{\mathcal{g},\mathcal{g}^*}(A_i) = \underline{1}$with $\Gamma_0 \subseteq \Gamma$ finite.

Definition: an If topology (X,$\mathcal{g}$,$\mathcal{g}^*$) is called an If regular if and only if each set $A \in I^X$ can be written as:

$A = \vee\{ B \in I^X : \mathcal{g}(B) \geq \mathcal{g}(A), \mathcal{g}^*(B) \leq \mathcal{g}^*(A), SPC_{\mathcal{g},\mathcal{g}^*}(B) \leq A\}$.

Theorem: if (X,$\mathcal{g}, \mathcal{g}^*$) is If almost semi-$\mathcal{g}$precompact and if regular then (X,$\mathcal{g}, \mathcal{g}^*$) is If semi-$\mathcal{g}$precompact.

Proof

Let $\vee_{i\in\Gamma} A_i = \underline{1}$ where $(\forall i \in \Gamma)(A_i \in I^X: \mathcal{g}(A_i) > r, \mathcal{g}^*(A_i) < s)$

Since (X, $\mathcal{g}$, $\mathcal{g}^*$) is If regular it follows that:

$A_i = \vee\{B_i \in I^X: \mathcal{g}(B_i) \geq \mathcal{g}(A_i), \mathcal{g}^*(B_i) \leq \mathcal{g}^*(A_i), SPC_{\mathcal{g},\mathcal{g}^*}(B_i) \leq A_i\}$

Since $\vee_{i\in\Gamma} A_i = \vee_{i\in\Gamma} B_i = \underline{1}$ and (X,$\mathcal{g}$, $\mathcal{g}^*$) is If almost semi-$\mathcal{g}$precompact

Then $\vee_{i\in\Gamma_0} SPC_{\mathcal{g},\mathcal{g}^*}(B_i) = \underline{1},\ \Gamma_0\ is\ finite\ subset\ of\ \Gamma$

But $SPC_{\mathcal{g},\mathcal{g}^*}(B_i) \leq A_i$

Thus, $\vee_{i\in\Gamma_0} SPC_{\mathcal{g},\mathcal{g}^*}(A_i) = \underline{1}$

Hence (X,$\mathcal{g}$, $\mathcal{g}^*$) is If semi-$\mathcal{g}$precompact.

Theorem: let (X,$\mathcal{g}$, $\mathcal{g}^*$) and (Y,φ , φ^*) be If topological spaces and $f: (X, \mathcal{g}, \mathcal{g}^*) \rightarrow (Y, \varphi, \varphi^*)$ be an If semi-$\mathcal{g}$preirresolute surjective mapping,

If (X,$\mathcal{g}$, $\mathcal{g}^*$) is If almost semi-$\mathcal{g}$precompact then so (Y,φ , φ^*).

Proof

Let $f: (X, \mathcal{g}, \mathcal{g}^*) \rightarrow (Y, \varphi, \varphi^*)$ be an If semi-$\mathcal{g}$preirresolute mapping of an If almost semi-$\mathcal{g}$precompact space (X,$\mathcal{g}$, $\mathcal{g}^*$) into If space (Y,φ , φ^*).

Let $\{B_i, i \in I, \varphi(B_i) \geq r, \varphi^*(B_i) \leq s\}$ be any of If semi-$\mathcal{g}$preopen cover of (Y,φ,φ^*).

References

Park, J. H. (2004). Intuitionistic fuzzy metric spaces. *Chaos, Solitons & Fractals, 22(5),* 1039-1046.

Ramadan, A. A., Abbas, S. E., & Abd El-Latif, A. A. (2005). Compactness in intuitionistic fuzzy topological spaces. *International journal of mathematics and mathematical sciences, 2005(1),* 19-32.

Atanassov, K. T. (1989). More on intuitionistic fuzzy sets. *Fuzzy sets and systems, 33(1),* 37-45.

Change, C.L. Fuzzy Topological Spaces. *Journal of Mathematical Analysis and Applications,*182-190.

Chattopadhyay, K.C., Hazra, R.N., & Samanta, S.K. (1992). Gradation of openness: fuzzy topology. *Fuzzy sets and Systems*, *49*(2), 237-242.

Coker, D. (1997). An Introduction to Intuitionistic Fuzzy Topological Spaces. *Fuzzy Sets and System, 88*, 81-89.

Demirci, M. (1997). On several types of compactness in smooth topological spaces. *Fuzzy sets and Systems*, *90*(1), 83-88.

Mnahi, A.K. (2017). On Intuitionistic Fuzzy Minimal Semi-preopen Set. *University of Thi-Qar Journal of Science*, *6*(3), 19-24.

Bae, Y., Jun, A., & Song, S.-Z. (2005). Intuitionistic fuzzy semi-preopen sets and intuitionistic fuzzy semi-precontinuous mappings. *Journal of Applied Mathematics & Computing, 19,* 467–474. https://doi.org/10.1007/BF02936305

Mondal, T.K., & Samanta, S.K. (2002). On intuitionistic gradation of openness. *Fuzzy sets and systems*, *131*(3), 323-336.

Zadeh, L.A. (1965). Fuzzy sets. *Information and control*, *8*(3), 338-353.