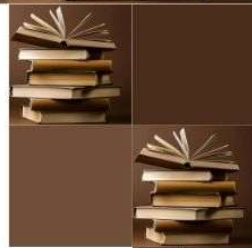
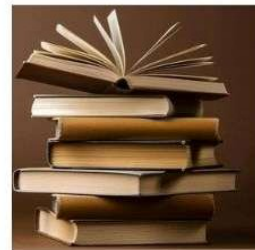


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DANIEL JAMES



ASDF UK

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A Study on Intuitionistic Soft Set Topological Spaces

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Abstract

In this study, we present the concept of Intuitionistic Soft Set Topological Spaces, which are defined as an Initial Universe, the power set, and a set of fixed objects. Interior and closure points are defined, and the concepts of Intuitionistic and Generalized Intuitionistic Soft Set Topology are introduced. The fundamental characteristics and outcomes of these notions are carefully examined. The study also investigates how many Intuitionistic Soft Sets can exist for a nonempty set with 'n' elements. It is demonstrated that this novel class of Intuitionistic Soft Topological Spaces parameterizes a family of topological spaces, and their properties and outcomes are thoroughly explored

Keywords: *Soft Set; Topological Space; Topological Soft Set; Topological Continuity; Connected Space*

1. Introduction

Due to our direct and limited perception, uncertainty is a defining characteristic of many problems in the modern world. Therefore, models that can guarantee certainty must be developed to simplify these complex problems. Unfortunately, mathematical models often fail to provide precise solutions. The ambiguity of data in fields such as economics, medical sciences, and others makes effective use of traditional methodologies difficult. All natural phenomena are surrounded by uncertainty, or constrained by the limitations of measurement. For instance, decision-making problems involving database data can face similar challenges. As a result, classical set theory—which relies on precise and definite values may not be entirely suitable for addressing problems involving uncertainty.

Numerous scholars have put forth a variety of theories to address uncertainty issues, such as (i) the theory of vague sets, (ii) the theory of interval mathematics, (iii) the theory of intuitionistic fuzzy sets, (iv) the theory of fuzzy sets, and (v) the theory of rough sets. In 1996, Coker presented Intuitionistic Set Theory, a versatile method for expressing ambiguity in mathematical objects and engineering domains, based on classical set logic. Later, he expanded this idea to topological spaces, creating Intuitionistic Topological Spaces. Molodtsov also proposed Soft Set Theory, a mathematical tool designed to complement the aforementioned uncertainty theories. He presented some fundamental findings of Soft Set Theory and demonstrated how it could be effectively applied in various fields, including function smoothness, operations research, and probability theory. A collection of estimated representations of an object is known as a soft set. This concept has been embraced and developed by numerous researchers over time, leading to significant advancements in its applications across various sectors. Soft set theory has been applied to decision-making problems by Maji et al. and Zou and Xiao, who have demonstrated how parameter reduction can aid in the selection of the best objects. Aktas and Cagman derived several properties and results by applying soft set theory to algebraic structures. The development of soft set topology has been advanced by generalizations of soft set theory, particularly in the study of concepts such as regularity, connectedness, continuity, compactness, and disconnectedness. Although they often provide only approximate solutions, both intuitionistic set theory and soft set theory are valuable tools for addressing uncertainty issues. The primary goal of this paper is to reduce the ambiguity of parameters.

We introduce Intuitionistic soft set topological spaces, which are characterized by the initial universe, the power set, and a collection of fixed objects. We begin by outlining some fundamental concepts related to intuitionistic sets, soft sets, topology, and previously researched findings. Then, we define the concepts of Intuitionistic soft set closed and open sets, and discuss several key properties of Intuitionistic and Generalized Intuitionistic soft set topological spaces. The Intuitionistic soft closure and interior sets are generalizations of the closure set, and the introduced parameters interact with the set of Intuitionistic soft set topological spaces on the initial universe, but not vice versa. This article is organized as follows: (ii) Basic concepts are introduced, (iii) Intuitionistic soft set topology is proposed, and some results are obtained, and (iv) Intuitionistic continuity.

2. Preliminaries

Definition:2.1

Let $\tau \subset U$ then following properties are satisfies to the topology in U as follows:

(i) $\varnothing \in \tau$ and $X \in \tau$

(ii) $V_j \cap V_i$ belongs to τ , $i \neq j$

(iii) if $\{V_\alpha\}$ is an arbitrary collection of members of τ then $\bigcup_\alpha V_\alpha$ belongs to τ

Definition: 2.2

Let E be a set of parameters and U be the universal set. Use P(U) to represent U's power set. If the mapping function F is defined as follows, then a pair (F,A) is referred to be a soft set over U and the set 'A' mapping from P(U), where 'A' is a subset of 'E'

Example: 1

A soft set (F, A) describes the number of subjects which are going to mapped in skill level.

Let $U = \{x_i\}$ & $A = \{e_i\}$ then the set 'A' is considered as (poor, average, good, very good)

Let $F(e_1) = \{x_2\}$, $F(e_2) = \{x_1, x_4\}$, $F(e_3) = \{x_1\}$, $F(e_4) = \{x_3\}$. Therefore $(F, A) \subset F(e_i)$

Definition: 2.3

Let (F,A) and (G,B) be two soft sets over the common universal set U. We say that (F,A) is a soft subset of (G,B) if the following conditions hold:

(i) A Contains to B (ii) For all a belongs A and F(a) is a subset of G(a)

Definition; 2.4 Let (F,A) & (G,B) be two soft sets over the common universal set U. If the two soft sets are equal, then F=G and A=B.

Definition: 2.5

Let $\tau(A)$ belongs to S (U) and then defined the power set is $\{\tau(A_i) \subseteq \tau(A) \mid i \in I\}$ and the cardinality of power $\tau(A)$ is defined as $2^{\sum_{x \in E} |\tau(A(x))|}$

Definition: 2.6

Let (U,E) be the universal set, and let τ be a power soft set over (U,E). Now, τ is said to be a **soft topology** over (U,E) if, for each element e belongs to E, the collection 'A' forms a topology of soft subsets over (U,E). In this case, τ is called a **soft topological space** over (U,E). The elements of 'e' are called the **soft open sets** of τ .

Example: 2

Let (U, E) be the set and (x_i, e_i) be the parameters, where $i = 1, 2, 3$.

Let ϕ and γ be the two soft sets such as $\phi = \{\{x_2\}, \{x_1, x_2\}, \{x_3\}\}$ and $\gamma = \{\{x_3\}, \{x_1\}, \{x_2\}\}$ $\tau(e_i) = (x_i)$.

By the (2.6) such as

$$\tau(e_1) = \{\phi, \alpha\}, \tau(e_2) = \{\phi, \alpha, \beta\} \text{ and } \tau(e_3) = \{\phi, \alpha, \beta, \delta\}$$

$$\text{Now, } \tau(e_1)(e_1) = \{\phi, U\}, \tau(e_2)(e_1) = \{\phi, U, \{x_1\}, \{x_2, x_3\}\}, \tau(e_3)(e_2) = \{\phi, U, \{x_1, x_2\}, \{x_2\}\}$$

Hence the result

Definition: 2.7

Let $\tau(\alpha)$ be a power set of soft topologies and it's by τ^* satisfies the following conditions

- (i) $\tau(\alpha), \tau(\phi) \in \tau^*$
- (ii) $\bigcup \tau(\alpha)$ and $\bigcap \tau(\alpha)$ belongs to τ^* It's called pair of soft topological space.

Definition: 2.8

Let U be the universal set and the Intuitionistic set of α is defined as $\alpha^* = \langle U, \theta_1, \theta_2 \rangle$ where θ_1 & θ_2 is represents the members and non-members values

Definition: 2.13

Let ' U ' be the non-empty set and it's a family of Intuitionistic topological space as follows:

- (i) $\phi, U \in \tau$
- (ii) $\tau_1 \cap \tau_2 \in \tau$
- (iii) $\bigcup \tau_i \in \tau$

The pair (U, τ) is called an Intuitionistic topological space for any Intuitionistic set in U .

Proposition: 2.1

Let $(U, \tau) \subseteq X$, then $\tau_{0,1} = \{[G]: G \in J\}$ and $\tau_{0,2} = \{\langle G \rangle: G \in J\}$ be the different topological space on X .

3. Intuitionistic Soft Set Topological Space

Let U represent the initial universe and E denote the set of all parameters. Consider $\alpha \subseteq E$ and

$IF(U) \in P(U)$. If there exists a mapping $F: \alpha \rightarrow IF(U)$ then $F(\alpha)$ is Intuitionistic soft set over C .

Definition: 3.1

Let ' U, E ' be the non-empty set and parameter. If $\alpha = (\theta_1, \theta_2) \subset E$ and $(U, \theta, E(\alpha_i), \alpha^*, \tau^*)$ then the collection of τ^* defined as $\alpha \rightarrow P(P(U^E))$ as follows:

- (i) $\theta, \alpha \in \tau^*$
- (ii) $IF(\alpha_i^*) \subseteq IF(\alpha^*) \Rightarrow \bigcup E(\alpha_i^*) \in \tau^*$
- (iii) $IF(\alpha_i^*) \subseteq IF(\alpha^*) \Rightarrow \bigcap E(\alpha_i^*) \in \tau^*$

Example: 5

Consider $U = \{x_1, x_2, x_3\}$ and $E = \{e_1, e_2, e'_1, e'_2\}$ then the list of τ^* space over X is

$$E(\alpha_1^*) = \{U, \theta, \langle (x_1, \{e_2\}), (x_2, \{e'_1\}) \rangle\}, E(\alpha_2^*) = \{U, \theta, \langle ((x_1, x_3), \{e_1\}), (x_2, \{e'_2\}) \rangle\}$$

$$E(\alpha_3^*) = \{U, \theta, \langle (x_2, \{e_2\}), ((x_1, x_2), \{e_2'\}) \rangle\} \text{ etc.,}$$

Definition: 3.2

Let $(\tau_i^*)_{i \in I} \subset IST(X)$ then $\cap \tau_i^* \in IST(X)$ belongs to the Intuitionistic soft topological space over X.

Then $\tau_1^* \subset \tau_2^*$ or $\tau_2^* \subset \tau_1^*$

Definition: 3.4

Let $\tau_1^* \& \tau_2^* \in IT(U)$ and $(\tau_1^*) \subset IST(U)$ then

(i) $\tau_1^* \subset \tau_2^*$ if $\gamma_1 \subset \theta_1$ and $\gamma_2 \supset \theta_2$ (ii) $\tau_1^* = \tau_2^*$ if $\tau_1^* \subset \tau_2^*$ and $\tau_1^* \supset \tau_2^*$

(iii) $(\tau^*)^c = (\gamma_2, \gamma_1)$ if $\gamma_1 \subset \theta_1$ and $\gamma_2 \supset \theta_2$

(iv) $\tau_1^*, \tau_2^* \in IST(U)$ then union of two Intuitionistic soft topological spaces is

$$\tau_1^* \cup \tau_2^* = (\gamma_1 \cup \theta_1, \gamma_2 \cap \theta_2)$$

$$(v) \tau_1^* \cap \tau_2^* = (\tau_1^* \cup \tau_2^*)^c \quad (vi) \cup \tau_i^* = (\cup \theta_1, \cap \theta_2) \quad (vii) \cap \tau_i^* = (\cup \theta_2, \cap \theta_1)$$

Theorem: 1

Let $(U, \theta, E(\alpha_i^*), \alpha^*, \tau^*) \in IST(U)$ then $E : \alpha^* \rightarrow P(P(U)^\delta)$ is a 3n way of elements.

Proof

Consider $U = (0, 1, 2, \dots, n-1)$ and $\alpha_i^* \in (n, n-1)$, $i = 1, 2, \dots, n$

Here, $U \neq \emptyset$ and $U : (n, n-1) \rightarrow [0, 1]$

Put $u = 0$, then $E(\alpha_i^*)(0) = \{(0, n), (i, n-1)\} = 2^n$

Put $u = 1$, then $E(\alpha_i^*)(1) = \{(1, n), (i, n-1)\} = \{(1, n) 2^{n-1}\}$

.....

Put $u = n-1$ then $E(\alpha_i^*)(n-1) = \{(n-1, n) 2^1\}$

Put $u = n$ then $E(\alpha_i^*)(n) = \{(n, n) 2^0\}$

Therefore, $\tau^* = \sum E(\alpha_i^*(u)) = (2+1)^n = 3^n$

Therefore, by the definition (2.3), theorem (1) proved.

Remark:

For a non-empty set U with n elements, an intuitionistic soft set topological space τ^* can have a maximum of 3^n intuitionistic soft open sets.

Example: 6 Let $U = \{u_1, u_2\}$, $F = \{x_1, x_2, x_3\}$ and $\alpha = \{x_1, x_2\} \subseteq F$ then the $\langle X, \tau^*, \alpha^* \rangle$ is 3^2

Proof:

Consider the Intuitionistic set is $E(\alpha) = \{(x_1, \{u_1, u_2\}), (x_2, \{u_2\})\}$ then the collection of Intuitionistic soft set topological space as follows:

$$E(\alpha_1) = \{\emptyset\}, E(\alpha_2) = \{E(\alpha)\}, E(\alpha_3) = \{(x_1, \{u_1\}), U, \emptyset\}, E(\alpha_4) = \{(x_1, \{u_2\}), U, \emptyset\},$$

$$E(\alpha_5) = \{(x_1, \{u_1, u_2\}), U, \emptyset\}, E(\alpha_6) = \{(x_2, \{u_2\}), U, \emptyset\}, E(\alpha_7) = \{U, \emptyset, (x_1, \{u_1\}), (x_2, \{u_2\})\},$$

$$E(\alpha_9) = \{U, \emptyset, (x_2, \{u_2\}), (x_1, \{u_2\})\} E(\alpha_8) = \{U, \emptyset, (x_1, \{u_1, u_2\}), (x_2, \{u_2\})\}$$

Hence Proved

Proposition: 3.1 :(i) Let $U = \{x_1, x_2, x_3\}$ and $E = \{e_1, e_2, e'_1, e'_2\}$ and $\alpha^* = (e_1, e'_2)$ then $\tau_1^* \cup \tau_2^* = U$ and $\tau_1^* \cap \tau_2^* = \phi$

Proof:

Given $U = \{x_1, x_2, x_3\}$, $E = \{e_1, e_2, e'_1, e'_2\}$ and $\alpha^* = (e_1, e'_2)$

$$\tau_1^* = E(\alpha_1^*) = \{U, \phi, (\{x_1\}, e_1), (\{x_2\}, e'_2)\}, \tau_2^* = E(\alpha_2^*) = \{U, \phi, (\{x_2\}, e_1), (\{x_3, x_1\}, e'_2)\}$$

So, $\tau_1^* \cup \tau_2^* = \{X, \phi, (\{x_1, x_2, x_3\}, (e_1, e'_2))\}$, $\tau_1^* \cup \tau_2^* = X$ and

$$\tau_1^* \cap \tau_2^* = \{X, \phi, (\{x_1\}, e_1), (\{x_2\}, e'_2)\} \cap (\{x_2\}, e_1), (\{x_3, x_1\}, e'_2) = \phi\}$$

Proposition: 3.2

Let $U = \{x_1, x_2, x_3\}$ and $E = \{e_1, e_2, e'_1, e'_2\}$ and $\alpha^* = (e_1, e'_2)$ then $\tau_1^* \cap (\tau_1^*)^c \neq \phi$ and $\tau_1^* \cup (\tau_1^*)^c \neq X$

Proof:

$$\tau_1^* = E(\alpha_1^*) = \{U, \phi, (\{x_1\}, e_1), (\{x_2\}, e'_2)\}, \tau_2^* = E(\alpha_2^*) = \{U, \phi, (\{x_2\}, e_1), (\{x_3, x_1\}, e'_2)\}$$

$$\tau \cap (\tau^*)^c = \{X, \phi, (\{x_1\}, e_1) \cap (\{x_1\}, e_1), ((\{x_2\}, e'_2) \cap (\{x_2\}, e'_2))\}$$

$$\tau \cap (\tau^*)^c = \phi$$

Similarly, $\tau \cup (\tau^*)^c \neq X$

Definition: 3.5

In an intuitionistic soft set topology $(U, \phi, E(\alpha_i^*), \alpha^*, \tau^*)$ over a universe U, a point u belongs to U is called an intuitionistic soft interior point of a set (G, α^*) if there exists an intuitionistic soft open set (E, α^*) such that $(E, \alpha^*) \subset (G, \alpha^*)$

Proposition: 3.3

In an intuitionistic soft set topological space $(U, \phi, E(\alpha_i^*), \alpha^*, \tau^*)$ over U, let (G, α^*) be an intuitionistic soft set over U. If U is an intuitionistic soft interior point of (E, α^*) , then U is also an interior point of (G, α^*) in (E, α^*) for every $\alpha \in A^* \subset E$

Proof:

Let $\alpha^* \subset F$, $G_A \subset U$. If $u \in U$ is a $IS(G_A, \alpha^*)$ then $\exists (E_A, \alpha^*) \in \tau^*$ such that $u \in (E_A, \alpha^*) \subset (G_A, \alpha^*)$

i.e) $u \in E_A \subset G_A$, As $E(\alpha) \in \tau_\alpha^*$. Therefore, E_A is Intuitionistic soft open for τ_α^* and $u \in E(\alpha)$

.Therefore, 'u' is an interior point of $IS(G_A) \in \tau_\alpha^*$

Proposition: 3.4

Let $(U, \phi, E(\alpha_i^*), \alpha^*, \tau^*)$ be an $IST(U)$ intuitionistic, then

(i) $u \in U$ has a soft neighborhood

(ii) If (E, α^*) and (F, α^*) be a neighborhood of 'U', then the intersection of $IT(U)$ is also a neighborhood of 'U'.

(iii) If (E, α^*) and (F, α^*) be a soft neighborhood of 'U', then the intersection of $IST(U)$ is also a neighborhood of 'U'.

Proof:

(i) Let $u \in U$ it's clearly true

(ii) Consider (E, α^*) and (F, α^*) be a neighborhood of (i), then $\exists (E_i, \alpha^*) \subset \tau_\alpha^*$ belongs to τ_α^* such that $u \in (E, \alpha^*)$

Now, $u \in (E_i, \alpha^*), i = 1, 2$ implies that $u \in (E_1, \alpha^*) \cap (E_2, \alpha^*) \in \tau^*$

Therefore, $u \in (E, \alpha^*) \cap (G, \alpha^*)$

Hence, U is an $IST(U)$.

(iii) By the result (ii) $u \in (E_1, \alpha^*) \subset (E, \alpha^*) \subset (G, \alpha^*)$

Therefore, $u \in (E_1, \alpha^*) \subset (G, \alpha^*)$

Hence $(G, \alpha^*) \in IST(U)$

Proposition: 3.5

Let $(U, E(\alpha_i^*), \tau^*) \in IST(U)$ and u & v be a non-empty set of 'U', then $(v, \tau_v^*(\alpha)) \subset (u, \tau_u^*(\alpha))$ is a subspace of $(X, \tau^*(\alpha))$ for $\alpha \in A^*$

Proof:

By proposition 3.4

$$\tau_{v_\alpha}^* = \{v \cap \tau_{\alpha(\gamma)} / (E, \alpha^*) \in \tau^* \} \subset F(\alpha) \in \tau^*(\alpha)$$

So, $(v, \tau_v^*(\alpha)) \subset (x, \tau_x^*(\alpha))$ for each $\gamma \in \alpha^*$

4. Topological Continuity

Definition: 4.1

Let X and Y are a non-empty set and τ^* & ρ^* be a two Intuitionistic soft set topological spaces. Then ' f ' is said to be continuous iff the pre-image of each Intuitionistic soft set is ρ^* an τ^*

Definition: 4.2

Let X and Y are a non-empty set and τ^* & ρ^* be a two Intuitionistic soft set topological spaces. Then ' f ' is said to be open iff image of each Intuitionistic soft set is ρ^* an τ^*

Example: 7

Let X and Y are a non-empty set and τ^* & ρ^* be a two Intuitionistic soft set topological space's and A^* and B^* is a two Intuitionistic set, then

(i) if ' f ' is continuous then τ^* as follows: $\tau^* = \{ \langle X, A^* \rangle : \phi_i \in \tau_0 \}$ and $\rho^* = \{ \langle Y, B^* \rangle : \phi_i \in \tau_0 \}$.

Such a case $\langle Y, B^* \rangle \in \rho, \phi \in \rho_0, f^{-1} \langle Y, B^* \rangle = \langle X, f^{-1}(A^*) \rangle \in \tau$

Proposition: 4.1

Let X and Y are a non-empty set and A^* and B^* is an two Intuitionistic set, then the following are equivalent such as

(a) $f : (X, \tau^*) \rightarrow (Y, \rho^*)$ is continuous

(b) $f^{-1}(\text{int}(A^*)) \subseteq \text{int}(f^{-1}(A^*))$ for each $A^* \subset X$

$(c) cl f^{-1}((A^*)) \subseteq f^{-1}(cl(A^*))$ for each $A^* \subset X$

Proposition: 4.2

Let $f : (X, \tau^*) \rightarrow (Y, \rho^*)$ be a continuous function.

Then $f : (X, \tau_1^*) \rightarrow (Y, \rho_1^*)$ and $f : (X, \tau_2^*) \rightarrow (Y, \rho_2^*)$ are also continuous, where $\tau_1^*, \tau_2^*, \rho_1^*, \rho_2^*$ are intuitionistic soft set topological spaces. $\tau_1^* = \{\phi_1 : \phi_1 \in A^*\}$, $\tau_2^* = \{(\phi_2)^c : \phi_2 \in A^*\}$, $\rho_1^* = \{\phi_1 : \phi_1 \in B^*\}$ and $\rho_2^* = \{(\phi_2)^c : \phi_2 \in B^*\}$

CONCLUSION

This paper introduces the concept of intuitionistic soft topological spaces, defined as a collection consisting of fixed objects, the power set, and the initial universe. It explores the notions of intuitionistic and generalized intuitionistic soft set topology, along with the concepts of interior and closure points, and presents fundamental results in this area. Further theoretical studies are necessary to develop a comprehensive framework for practical applications.

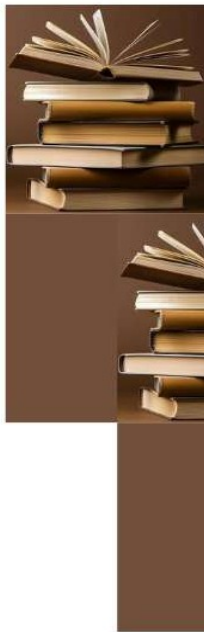
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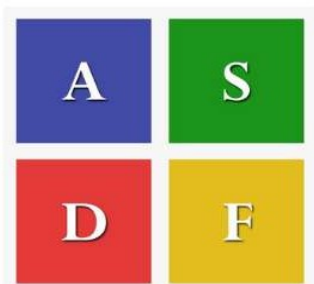


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