**ON INTUITIONISTIC FUZZY SOFT** **CLOSED SETS IN INTUITIONISTIC FUZZY SOFT TOPOLOGICAL SPACES**

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**Abstract**

The aim of this paper is to introduce and study some new concepts like (IFSbCT), (IFSbC)–continuous, (IFSbC)–mapping, (IFSbC–SC, (IFSbC)–C, (IFSbC)–. Furthermore, we generated (induced fuzzy soft set by) and (induced intuitionistic fuzzy soft set by , where  is a soft set over the universe of the given set with a fixed set of parameters and  is a fuzzy soft set . In another side  is an induced intuitionistic fuzzy soft set by). Moreover, some of its basic properties are given.

Keywords: soft set, fuzzy soft set, intuitionistic fuzzy soft, absolute IF soft set, cardinality of soft set.

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1. **Introduction**

A fuzzy set is a class of objects with a continuum of grades of membership this concept is proposed by Zadeh [12] in 1965. After the introduction of fuzzy topology by Chang [3] in 1968, there have been several generalizations of notions of fuzzy set and fuzzy topology. By adding the degree of non-membership to fuzzy set, Atanassov [11] proposed intuitionistic fuzzy set in 1986 which looks more accurate to uncertainty quantification and provides the opportunity to precisely model the problem based on the existing knowledge and observations. In 1997, Coker [6] introduced the concept of intuitionistic fuzzy topological space. In 1999, Molodtsov [7] initiated a concept namely, soft set theory to solve complicated problems in engineering, physics, computer science, medical science etc. To improve this concept, many researchers applied this notion on group theory [9], ring theory [18], topological spaces [19] and also on decision making Problem [15]. Moreover, in 2013, Li and Cui [20] introduced the fundamental concept of Intuitionistic fuzzy soft topology. In the present work the new concepts like (IFSbCT), (IFSbC)-continuous, (IFSbC)-mapping, (IFSbC- SC, (IFSbC) –C, (IFSbC),,  are introduced. Also we gave some basic properties of these concepts.

**2. Definitions and Notations**

The following definitions have been used to obtain the results and properties developed in this paper.

**Definition 2.1: (**[1], [5])

Let  be a subset of a topological space, then  is called a open set if. The complement of a open set is said to be closed. The intersection of all closed sets of  containing  is called the closure of  and is denoted by. The union of all open sets of  contained in  is called interior of  and is denoted by.

**Example: 2.2**

Let  and  be two topological spaces where ,  and . Then  is an open b-closed set inbut is not b-closed set in.

**Definition 2.3:** ([7], [4])

A pair  is called a soft set (over ) where  is a mapping . In other words, the soft set is a parameterized family of subsets of the set . Every set , , from this family may be considered as the set of e-elements of the soft set , or as the set of approximate elements of the soft set. Clearly, a soft set is not a set. For two soft sets and over the common universe, we say that is a soft subset of if  and for all, and are identical approximations. We write . is said to be a soft superset of , if is a soft subset of . Two soft sets and over a common universe  are said to be soft equal if is a soft subset of and is a soft subset of. A soft set  over  is called a null soft set, denoted by (,), if for each. Similarly, it is called universal soft set, denoted by, if for each .The collection of soft sets over a universe  and the parameter set  is a family of soft sets denoted by .

**Remark 2.4:** [8]The Cardinality of is given by  .

**Example 2.5:** if *U*= {*,* *,* , }and , then  256 . **Definition 2.6:** [14]

Let  be the collection of soft sets over . Then  is called a soft topology on  if  satisfies the following axioms:

(i) ,  belong to . (ii) The union of any number of soft sets in  belongs to . (iii) The intersection of any two soft sets in  belongs to .

The triplet  is called a soft topological space over . The members of are

called soft open sets in  and complements of them are called soft closed sets in .

**Definition 2.7:** [16] Let  be an initial universe set and let  be a set of parameters.

Let  denotes the collection of all fuzzy subsets of  and . Then the mapping defined by  (a fuzzy subset of), is called a fuzzy soft set over , where  if  and  if . The set of all fuzzy soft sets over  is denoted by.

**Definition 2.8:** [16] The fuzzy soft set  is said to be null fuzzy soft set and it is denoted by , if for all , is the null fuzzy set  of , where  for all .

**Definition 2.9:** [16] Let   and  for all , where  for all . Then  is called absolute fuzzy soft set. It is denoted by .

**Definition 2.10:** [16] A fuzzy soft set  is said to be a fuzzy soft subset of a fuzzy soft set  over a common universe  if  for all , i.e., if  for all  and for all .

**Definition 2.11:** [16] Two fuzzy soft sets  and  over a common universe  are said to be fuzzy soft equal if  is a fuzzy soft subset of  and  is a fuzzy soft subset of .

**Definition 2.12:** [16] The union of two fuzzy soft sets  and  over the common universe  is the fuzzy soft set , defined by  for all , where . Here we write .

**Definition 2.13:** [16] Let  and  be two fuzzy soft set, then the intersection of  and  is a fuzzy soft set , defined by  for all , where . Here we write .

**Definition 2.14:** [2]

Let  be the collection of fuzzy soft sets over . Then  is called a fuzzy soft topology on  if  satisfies the following axioms:

(i) ,  belong to . (ii) The union of any number of fuzzy soft sets in  belongs to . (iii) The intersection of any two fuzzy soft sets in  belongs to .

The pair is called a fuzzy soft topological space over. The members of  are called fuzzy soft open sets in  and complements of them are called fuzzy soft closed sets in .

**Definition 2.15:** (IF set). [11] An intuitionistic fuzzy (IF, in short) set A over the universe  can be defined as follows  where :   [0; 1], :   [0; 1] with the property 0 +  1, . The values and represent the degree of membership and non-membership of  to  respectively.

**Definition 2.16:** [11]

Let  and  be intuitionistic fuzzy sets of .

(1)  if and only if  and  for all ,

(2)  

(3)  

**Definition 2.17:** [11] An intuitionistic fuzzy set  over the universe  defined as  is said to be intuitionistic fuzzy null set and is denoted by .

**Definition 2.18:** [11] An intuitionistic fuzzy set  over the universe  defined as  is said to be intuitionistic fuzzy absolute set and is denoted by .

**Definition 2.19:** (IF soft set). [17] Let  be an initial universe set and  be the set of parameters. Let  denote the collection of all IF subsets of . Let . A pair  is called an IF soft set over  where F is a mapping given by. In general, for every , is an IF set of  and it is called IF value set of parameter e. Clearly,  can be written as an IF set such that . The set of all IF soft sets over  with parameters from E is called an IF soft class and it is denoted by IFS().

**Definition 2.20:** [17] The union of two IF soft sets andover the common universe U is the IF soft set

=, where C = AB and for all e  C,



**Definition 2.21:** [17]

Let  and  be two IF soft set, then the intersection of  and  is a IF soft set  =. Where and 

for all .

**Definition 2.22:** [17]

A IF soft set  is said to be a IF soft subset of a IF soft set  over a common universe U if  and , for all .

**Definition 2.23:** [17]

The complement of an intuitionistic fuzzy soft set  is denoted by and is defined by = , where :is a mapping given by = for all . Thus if , then ,

.

**Definition 2.24:** [17] (Absolute IF soft set):

A IF soft set over  is said to be null intuitionistic fuzzy soft set and is denoted by  if , is the absolute intuitionistic fuzzy set of  where ;. We would use the notation  to represent the absolute intuitionistic fuzzy soft set with respect to the set of parameters A.

**Definition 2.25:** [17] (Null IF soft set):

A IF soft set over  is said to be null intuitionistic fuzzy soft set and is denoted by  if ; is the null intuitionistic fuzzy set  of  where We would use the notation  to represent the null intuitionistic fuzzy soft set with respect to the set of parameters .

**Definition 2.26:** [20]

Let , then  is said to be a IF soft topology on , if  satisfies the following axioms:

i.  belong to  .

ii. The union of any number of IF soft sets in  belongs to  .

iii. The intersection of any two IF soft sets in  belongs to .

 is called a IF soft topology on  and the binary (,) is called a IF soft topological space over . Any member belongs tois said to be IF soft open set (IFSOS) in. A IF soft set over  is said to be a IF soft closed set (IFSCS) in U, if its complement  belongs to. Let us refer to IF soft topological space by IFSTS.

**Definition 2.27:** [13]

Let and be two IF soft sets over . We define the difference of and as the IF soft written as

where  and , ,

,

**.**

That means,  and 

**Definition 2.28: [**10] A IF soft set is said to be a IF soft point, denoted

by , if for the element ,  and .

**Definition 2.29:** [10] The complement of a IF soft point  is a IF soft point such that .

**3. INTUITIONISTIC FUZZY SOFT b- CLOSED SETS**

In this section, we introduce some new concepts like (IFSbCT), (IFSbC)-continuous, (IFSbC)-mapping, (IFSbC- SC, (IFSbC) –C, (IFSbC) , ,  and study some of their properties. Moreover, the current work is supported by a number of examples.

**Definition 3.1**

In a soft topological space , a soft setis said to be soft closed set if

.

**Definition 3.2**

A soft topological space, is called soft closed topological space if for each  is soft b-closed set.

**Example 3.3**

Let the set of students under consideration be *,* *,* . Let pleasing personality (); conduct (); good result (); sincerity ()} be the set of parameters framed to choose the best student. Suppose that the soft set describing the Mr.opinion to choose the best student of an academic year was defined by



{*,* *,*}

In addition, we assume that the “best student” in the opinion of another teacher, say Mr.Y, is described by the soft set , where



{*,* *,*},{*,* *,*}

 Consider that:

. Then  is soft closed topological space.

**Definition 3.4**

In a fuzzy soft topological space , a fuzzy soft set  is said to be fuzzy soft closed set if ,

i.e., if.

**Definition 3.5**

A fuzzy soft topological space, is called fuzzy soft closed topological space if for each  is fuzzy soft closed set.

**Example 3.6**

Let *U*= {*,**,* } be the set of three flats and *E* = {costly (), modern (), cheap ()} be the set of parameters ,where *E*. consider that

 is a fuzzy soft topology over (U, E) where are fuzzy soft sets over (U, E), defined as follows**:**

 **,** 

, 

, 

, 

Then is fuzzy soft closed topological space.

**Definition 3.7** (IFSbCS, in short)

In an intuitionistic fuzzy soft topological space, an intuitionistic fuzzy soft set is said to be intuitionistic fuzzy soft closed set if

.Moreover, the complement of the intuitionistic fuzzy soft closed sets is called intuitionistic fuzzy soft open sets (IFSbOS, in short).

**Definition 3.8** (IFSbCT, in short)

An intuitionistic fuzzy soft topological space, is called intuitionistic fuzzy soft topological space if for each is intuitionistic fuzzy soft closed set.

**Example 3.9**

Suppose that  is the set of men whose looking for job under consideration, say . Let E be the set of some attributes of such men, say , where  stand for the attributes “young”, “speaking English well”, “qualification”, “honest”, respectively.

Let be the mappings from A to defined by,

































Then  is a IF soft topology over . Moreover, any member in is IF soft closed. Hence is IFSbCT.

**Definition 3.10 [(IFSbC)-continuous]**

Let be a mapping from IFSTS into IFSTS. Then  is called an intuitionistic fuzzy soft closed continuous mapping if  and is a IFSbCS in for each IFSbCS in .

**Definition 3.11[ (IFSbC)-mapping]**

Let be a mapping from IFSTS into IFSTS . Then  is called an intuitionistic fuzzy soft closed mapping if  and is a IFSbCS in for each IFSbCS  in .

**Theorem 3.12**

Let be a mapping from IFSTSinto IFSTS . Then the following statements are equivalent.

1.  is an intuitionistic fuzzy soft closed continuous mapping.
2.  is a IFSbOS in  for every IFSbOS  in .

**Proof:**

Suppose that  is an intuitionistic fuzzy soft closed continuous mapping and let  be a IFSbOS  in . Then is IFSbCS in , but  is an intuitionistic fuzzy soft b-closed continuous mapping. Hence  is IFSbCS and open in. However, , thus is a IFSbOS in . Conversely, assume that  is a IFSbOS infor every IFSbOS  in. Now, for any IFSbCS  in we obtain is IFSbOS in . Hence  is IFSbOS in . However,, thus is a a IFSbCS in . Then  is an intuitionistic fuzzy soft closed continuous mapping.

**Definition 3.13**

A family of IF soft open sets is an open cover [(IFSO) – C, in short] of a IF soft set  if . A subcover of  is a subfamily of which is also a cover. A subcover of  is called IF soft closed subcover [(IFSbC)–SC, in short] if each member of is a IFSbCS. Moreover, we refer to  by (IFSbC– SC, if  has finite members.

**Definition 3.14:** Let be IFSTS and . A IF soft set is called IF soft closed compact [(IFSbC)–C, in short], if each (IFSO) – C of has a (IFSbC–SC. Also IFSTS is called IF soft closed compact [(IFSbC) –C, in short], if each (IFSO) – C of  has a (IFSbC–SC.

**Example 3.15**

Let be IFSTS with finite universe set , then is (IFSbC) – C.

**Proposition 3.16:** Let be a IFSCS in  (IFSbC) – C . Then is also (IFSbC) –C.

**Proof:**

Let be (IFSO) – C of . But with  is a (IFSO) – C of , since is a IFSOS, say  is a (IFSO) – C of . That means . However, is (IFSbC) – C, thus  has a (IFSbC- SC, say of such that :



Now, it's clearly if  is not (IFSbCS). Then is (IFSbC) – C. Moreover, if  is (IFSbCS). Then we have. This implies that. Now, for each IF soft point we have  . That means does not cover its complement in any IF soft point. Hence  is (IFSbC–SC of such that. Then is (IFSbC) – C.

**Theorem 3.17**

Let be a (IFSbC)- continuous mapping from IFSTS  onto IFSTS . If is (IFSbC)-C, then  is verifies the same property.

**Proof:**

 be (IFSO)–C of ; i.e . Therefore , this implies that .

So  for all  (since  is (IFSbC)-continuous). However,  is (IFSbC)–C, thus  has a (IFSbC–SC say  of . AS , this implies that  (since  is onto). So we have has a (IFSbC– SC of . Hence  is (IFSbC) –C.

**Definition 3.18**

Let be a IFSTS over U. Then is said to be IF soft b-closed disconnected [(IFSbC), in short], if there exists a pair ,of no-null (IFSbCS) each one of them belongs to  and such that ,.

**Example 3.19:** Let us consider the IFSTS  that is given in Example 3.3, we have there does not exist a pair,of no-null (IFSbCS) each one of them belongs to  such that  and . Then  is (IFSbC) .

**Remark 3.20**

Let be a IFSTS over U. Then, for any is both (IFSbCS) and (IFSbOS) if  and its complement belong to 

**Theorem 3.21**

Let be a IFSTS over U. Thenis (IFSbC)-C if and only if there is no proper (IFSbCS) that is both (IFSO) and (IFSC).

**Proof:**

Let be a (IFSbC)-C and  be a proper (IFSbCS) that is both (IFSO) and (IFSC). Clearly, and is a (IFSbCS) different from  and . Also, ,. Therefore we have  is a (IFSbC) . This is a contradiction. Hence  and  the only (IFSbCS) are both (IFSO) and (IFSC).

Conversely, assume that is a (IFSbC) , then there exists a pair ,of no-null (IFSbCS) each one of them belongs to  and such that ,. Let , thus 

(but this is a contradiction). So . Hence . That means is both (IFSO) and (IFSC) different from  and . That is a contradiction. Then is (IFSbC)-C .

**Definition 3.22**

Let  be a soft set over . Then  is called an induced fuzzy soft set over , where is a mapping which is given as:

for the image of  under  denoted by, is defended as following:

 (a fuzzy subset of ), where  ifand



For all , if.

**Example 3.23**

Letand that be given in (Example 3.3) and letbe a soft set over  where .Then **.** Where  and .

**Remark 3.24**

It's clearly for any soft set subset of soft set we can consider that.

**Definition 3.25**

Let  be a fuzzy soft set over . Then  is called an induced intuitionistic fuzzy soft set over , where  is a mapping which is given as: for the image of  under  denoted by, is defended as following:

, for all .

**Remark 3.26**

For any soft set we can generated IF soft set by using the composition of two mappings  and .

**Propositions 3.27:** Let U be an initial universe set and let E be a set of parameters. Then the following statements are hold:

1. The image of Null soft set = (,) under  is Null fuzzy soft set.
2. The image of Null fuzzy soft set under  is Null intuitionistic fuzzy soft set.
3. The image of Null soft set = (,) under the composition  is Null intuitionistic fuzzy soft set.
4. The image of Absolute soft set under  is Absolute fuzzy soft set .
5. The image of Absolute fuzzy soft set  under  is Absolute intuitionistic fuzzy soft set.
6. The image of Absolute soft set  under the composition  is Absolute intuitionistic fuzzy soft set.

**Definition 3.28**

Let  be a soft topological space over and  be a fuzzy soft topological space. Then  is said to be an induced fuzzy soft topological space by  if and only if .

**Definition 3.29**

Let  be a fuzzy soft topological space over and  be a IF soft topological space. Then  is said to be an induced IF soft topological space by  if and only if .

**Definition 3.30**

Let  be a soft topological space over and be a IF soft topological space. Then  is said to be an induced IF soft topological space by  if and only if .

**Proposition 3.31**: Let U be an initial universe set and let E be a set of parameters. For any pair of soft sets  and, the following statements are hold:

(1)- If, then,

(2)- ,

(3)- .

**Proof (1):**

Since, then and , we consider that whenever (since). If , then there are four cases as following:

**Case (1)**

 , if . However,  this implies that . So, if .

**Case (2)**

 , if . However,  this implies that either or , if we have . Also, if  this implies that . Then, thus, if .

**Case (3)**

 , if . However,  this implies that . Now, if we consider thatand if we have. Therefore, if .

**Case (4)**

 , if . That means , for all . Finally we consider that , for all and . Then.

**Proof (2):**

Since . Hence 

Where  is an induced fuzzy soft topological space by. However, . Then .

**Proof (3):**

Since . Hence 

Where  is an induced fuzzy soft topological space by. However,. Then .

**Proposition 3.32**: Let  be a soft closed topological space, then the induced fuzzy soft topological space by  is a fuzzy soft closed topological space.

**Proof:**

Let be an induced fuzzy soft topological space by. Then .

That means for any soft set we have. Also, for any fuzzy soft set , there exists soft set such that . Now we want to show that for any  satisfies that .

However,  this implies that . Since  is a soft closed topological space, thus such that . Hence   (by Proposition 3.31), but . Then for any  satisfies that . Therefore the induced fuzzy soft topological space by  is a fuzzy soft closed topological space**.**

**Proposition 3.33**: Let U be an initial universe set and let E be a set of parameters. For any pair of fuzzy soft sets  and, the following statements are hold:

(1)- If, then,

(2)- ,

(3)- .

**Proof (1):**

**Since**, then for all  and for all , and this implies that for all  and for all . Hence.

**Proof (2):**

Since. Hence 

Where  is an induced intuitionistic fuzzy soft topological space by. However, . Then .

**Proof (3):**

Since . Hence 

Where  is an induced intuitionistic fuzzy soft topological space by. However, . Then .

**Proposition 3.34**: Let  be a fuzzy soft closed topological space, then the induced fuzzy soft topological space by  is a (IFSbCT).

**Proof:**

Let be an induced intuitionistic fuzzy soft topological space by. Then . That means for any fuzzy soft set  we have. Also, for any intuitionistic fuzzy soft set , there exists fuzzy soft set such that . Now we want to show that for any  satisfies that . However,  this implies that . Since  is a fuzzy soft closed topological space, thus such that . Hence   (by Proposition 3.33), but . Then for any  satisfies that . Therefore the induced intuitionistic fuzzy soft topological space by  is a (IFSbCT).

**Proposition 3.35**: Let be a (IFSbC)- mapping from IFSTS  into IFSTS and let be a (IFSbC)– continuous mapping from IFSTSinto induced IFSTSby fuzzy soft b–closed space . Then for any fuzzy soft set there exists IFSbCS  in  such that.

**Proof:**

Suppose that. Then is a fuzzy soft b–closed set ( since is fuzzy soft b-closed space) . However,  (sinceis an induced by). Moreover, is a IFSbCS in (by Proposition 3.34). Further,  and  is a IFSbCS in (since is a (IFSbC)– continuous ). This implies that  and  is a IFSbCS in  (since is a (IFSbC)–mapping). Assume that. Then for any fuzzy soft set there exists IFSbCS  in  such that.

**4. Conclusion**

In this work, we introduced some new concepts like (IFSbCT), (IFSbC)-continuous, (IFSbC)–mapping, (IFSbC– SC, (IFSbC) –C, (IFSbC), , . Also we gave some basic properties of these concepts. Moreover, it is interesting to work on the compositions of soft sets and Intuitionistic fuzzy sets. Also, The composition of two mappings  and  can be tried with other forms of soft sets like soft closed  and check  is need to be (IFSbCS). In another side let be a

soft topological space over , then the induced IF soft topological space by  is need to be (IFSbCS).

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