Review of Literature

A review of literature of recent developments on generalized notions of closed and open sets, continuous mappings, closed mappings in topological spaces, fuzzy topological spaces and intuitionistic fuzzy topological spaces is given below.

Topological Spaces

Closed sets are fundamental objects in topological spaces. In the study of topological spaces many concepts of topology have been generalized by introducing the concept of semi open sets (Levine (1963)) instead of open sets. The concept of generalized closed sets introduced by Levine (1970) plays a significant role in general topology. Using this concept and Levine's idea, many researchers have introduced and studied various types of generalized closed sets. Andrijevic (1986, 1996) has introduced semipre open sets and b-open sets. Bhattacharya and Lahari (1987) have introduced semi generalized closed sets in topology. Palaniappan and Rao (1993) have introduced regular generalized closed sets. Maki et.al (1993, 1994) have introduced generalized α closed sets and α generalized closed sets in topological spaces. Dontchev (1995) has introduced generalized semipre open sets. Fukutake, Nasef and El-Maghrabi (2003) introduced γ generalized closed sets in topological spaces. Ganster and Steiner (2007) investigated many relationships between b generalized closed sets with generalized notions of closed sets. Ahmad Al-Omari et.al (2009a) introduced generalized b-closed sets. Narmatha, Nagaveni and Noiri (2013) have introduced regular b-open sets in topological spaces.

The notion of continuous maps is one of the most important concepts in topological spaces. Mashhour, Abd El- Monsef and El-deep (1982) have investigated pre continuous and weak pre continuous mappings in topology. Noiri (1984) has introduced α continuous functions and α irresolute functions in topology. Reilly and Vamanamurthy (1985) have introduced α continuity in topological spaces. Balachandran, Sundaram, and Maki (1991) have introduced generalized continuous maps in topological spaces. Fukutake, Nasef and EL-Maghrabi (2003) have introduced γ generalized continuous maps in topological spaces. Ekici and Caldas (2004) introduced slightly γ continuous functions.

Dontchev (1996) introduced a new type of mappings called contra continuous mappings. Also, a new weaker form of this class of mappings called contra semi continuous mappings are introduced and investigated by Dontchev and Noiri (1999). Jafari and Noiri (2001, 2002) have introduced contra α continuous, contra pre continuous mappings in topological spaces. Ekici (2004) has introduced contra-continuity in topological space. The concept of contra γ continuous functions was introduced by Nasef (2005). Ahmad Al-Omari and Noorani (2009b) have investigated some properties of contra b-continuous functions. El-Magbrabi (2010) has studied and analyzed some properties of contra continuous mappings in topological spaces.

Singal and Singal (1968) have introduced almost continuous mapping in topological spaces. Thakur, Samajh Singh and Paik (1987) have introduced almost alpha continuous mappings. Paul and Mc Gehee (1970) have investigated some properties of almost continuous functions. Jafari and Noiri (2000) have introduced almost pre continuous functions. Almost γ continuous functions in topological spaces were introduced by Hariwan (2012) which is contained in the class of almost continuous functions and contains the class of γ continuous functions. Keskin and Noiri (2009) have introduced almost b-continuous functions.

Several strong variants of continuity have been introduced and studied by many authors, which in general are stronger than continuity but weaker than strong continuity. Arya and Gupta (1974) have introduced and studied strongly continuous mappings in topological spaces.

Open maps and closed maps are very interesting concepts in topology. Noiri (1973) has introduced a class of mappings called semi-closed mappings which contain the class of closed mappings. Malghan (1982) has introduced generalized closed maps in topology. Mashour, Hasanein and El. Deep (1983) have introduced α continuous and α open mapping in topological spaces. Sen and Bhattacharya (1983) have first introduced pre closed mappings. Devi, Balachandran and Maki (1998) have introduced and investigated the concept of generalized alpha closed maps, alpha generalized closed maps and alpha regular spaces as generalization of closed maps, generalized closed maps and

regular spaces. Semi generalized closed maps and generalized semi closed maps are introduced by Devi, Balachandran and Maki (1993). Devi, Balachandran and Maki (1998) have introduced generalized alpha closed maps and alpha generalized closed maps in topological spaces.

The notion of homeomorphisms plays an important role in topological spaces. Maki et al. (1991) introduced generalized homeomorphisms and studied their properties. Balachandran, Sundaram and Maki (1991) introduced GO connectedness in topological spaces. Narmadadevi, Roja and Uma (2013) introduced γ basically disconnected spaces.

Fuzzy topological spaces

The concept of fuzzy set which was first introduced by Zadeh (1965) is a mathematical means of describing vagueness in linguistics. Subsequently, several researchers have worked on various basic concepts from classical topology using fuzzy sets and developed fuzzy topological spaces. The notion of fuzzy sets plays a very significant role in the study of fuzzy topology introduced by Chang (1968), who studied a number of basic concepts, including fuzzy continuous maps and compactness.

Lowen (1982) has introduced fuzzy neighbourhood spaces. Ganguly and Saha (1986) has introduced fuzzy semi open sets in fuzzy topological spaces. Singal and Niti Prakash (1991) have introduced fuzzy pre open sets. Fuzzy α open sets and fuzzy pre open sets were introduced by Bin Shahna (1991). Thakur and Malviya (1995) have introduced generalized closed sets in fuzzy topology. Maki et.al (1998) introduced generalized closed sets in fuzzy topological spaces. Fuzzy semipre open set is introduced by Thakur and Singh (1998).

Warren (1978) gave the characterizations of fuzzy continuous functions characterized by the closure of fuzzy sets, a sub basis of a fuzzy topology and fuzzy neighbourhoods. Saraf, Govindappa Navalagi and Meena Khanna (2005) have introduced fuzzy semipre generalized closed sets. Bayaz Daraby and Nimse (2007) have discussed fuzzy generalized alpha closed set and its applications. Benchalli and Jenifer Karnel (2010a) have introduced fuzzy b-open sets in fuzzy topological spaces.

Munir Abdul-Khalik, Al-Khafaji and Jaafer Jabbar Cassem (2014) have introduced fuzzy generalized b- closed set in fuzzy topological spaces.

Fuzzy semi continuity, fuzzy almost continuity and fuzzy weekly continuity are introduced by Azad (1981). Bin Shahna (1991) has introduced fuzzy strong semi continuity and fuzzy continuity. Prasad, Thakur and Saraf (1994) introduced fuzzy α irresolute mappings. Balasubramanian and Sundaram (1997) have investigated some generalizations of fuzzy continuous functions. Thakur and Singh (1998) have introduced semi pre continuous mappings in fuzzy topological spaces. Abd EI-Hakeim (1999) has introduced generalized semi continuous mappings in fuzzy topological spaces. Ekici and Kerre (2006) have introduced fuzzy contra continuities. Ahmad and Athar (2008) have introduced fuzzy almost continuous function in fuzzy topological space. Hanafy (2009) has introduced fuzzy γ continuity and contributed some beautiful results in fuzzy topological spaces. Bhaumik and Mukherjee (1993a, 1993b) have introduced fuzzy completely continuous mappings and fuzzy weakly completely continuous function in fuzzy topology.

Nanda (1986) studied fuzzy almost open mappings. Mukherjee and Sinha (1989) have introduced irresolute and almost open functions between fuzzy topological spaces. Ghosh (1990) has introduced semi closed mappings in fuzzy setting. Fuzzy α open mappings were introduced by Singal and Niti Rajvanshi (1992). Park (1997) has introduced fuzzy weakly open mappings in fuzzy topological spaces.

Benchalli, Jenifer Karnel and Siddapur (2012) introduced fuzzy b-generalized homeomorphism in fuzzy topological spaces. Raja Sethupathy and Lakshmivarahan (1977) have introduced connectedness in fuzzy topological spaces. Zhao (1986) has contributed some beautiful results in connectedness on fuzzy topological spaces. Hanafy (2003) introduced the concept of γ connectedness in fuzzy topological spaces.

Intuitionistic fuzzy topological spaces

Atanassov (1986, 1988, 1989, 1994) has introduced intuitionistic fuzzy sets and also gave new results in intuitionistic fuzzy sets and operations. Intuitionistic fuzzy points are introduced by Coker and Demirci (1995). Intuitionistic fuzzy open sets and

intuitionistic fuzzy closed sets are introduced by Coker (1997). Intuitionistic fuzzy semi open sets, intuitionistic fuzzy pre open sets, intuitionistic fuzzy α open sets are introduced by Joung Kon Jeon (2005). Young Bae Jun and Seok- Zun Song (2005) have introduced intuitionistic fuzzy semi-pre open sets. Thakur and Rekha Chaturvedi (2008) have introduced generalized closed sets in intuitionistic fuzzy topology. Hanafy (2009) studied the properties of intuitionistic fuzzy γ closed sets and intuitionistic fuzzy γ open sets. Santhi and Jayanthi (2009) have introduced intuitionistic fuzzy generalized semi pre closed sets in intuitionistic fuzzy topological spaces. Santhi and Arun Prakash (2010) have introduced intuitionistic fuzzy semi-generalized closed sets and their applications. Rajarajeswari and Senthil Kumar (2011) have introduced generalized pre-closed sets in intuitionistic fuzzy topological spaces. Thirumalaiswamy and Ramesh (2013) have introduced semi pre generalized closed sets in intuitionistic fuzzy topological spaces. The concept nowhere dense in intuitionistic fuzzy topological space is introduced by Thakur and Dhavaseelan (2015). Kanimozhi and Jayanthi (2016) have introduced and studied the concepts of intuitionistic fuzzy generalized γ closed sets, intuitionistic fuzzy generalized γ open sets and investigated their properties.

Hur and Jun (2003) have studied intuitionistic fuzzy alpha-continuous mappings. Intuitionistic fuzzy continuous mappings and intuitionistic fuzzy irresolute mappings are studied by Gurcay, Coker and Hayder (1997). Joung Kon Jeon, Young Bae Jun and Jin Han Park (2005) have introduced intuitionistic fuzzy α continuity and intuitionistic fuzzy pre continuity. Jun, Kang and Song (2005) have introduced intuitionistic fuzzy irresolute and continuous mappings. Thakur and Rekha Chaturvedi (2006) have introduced generalized continuity in intuitionistic fuzzy topology. Krsteska and Salah Abbas (2007) have introduced intuitionistic fuzzy strongly irresolute pre continuous mappings in Coker's space. Hanafy (2009) has introduced intuitionistic fuzzy γ continuity in intuitionistic fuzzy topological spaces. Santhi and Arun Prakash (2011a) have introduced and investigated intuitionistic fuzzy semi-generalized irresolute mappings.

Krsteska and Ekici (2007) have introduced intuitionistic fuzzy contra continuous mappings. Santhi and Sakthivel (2009a, 2009b) have introduced intuitionistic fuzzy

generalized semi continuous mappings and intuitionistic fuzzy contra alpha generalized continuous mappings. Sakthivel (2010) has introduced intuitionistic fuzzy alpha generalized continuous mappings and intuitionistic fuzzy alpha generalized irresolute mappings. Santhi and Jayanthi (2010) have introduced intuitionistic fuzzy generalized semi pre continuous mappings. Intuitionistic fuzzy contra semi-generalized continuous mappings were introduced by Santhi and Arunprakash (2011b). Roja, Uma and Dhavaseelan (2012) have introduced generalized intuitionistic fuzzy contra continuity.

Hanafy and El- Arish (2003) have introduced completely continuous functions in intuitionistic fuzzy topological spaces. Shrivastava and Jyoti Gupta (2016) have introduced intuitionistic fuzzy almost continuity and weakly continuity.

Seok Jong Lee and Eun Pyo Lee (2000) have introduced intuitionistic fuzzy open mapping and intuitionistic fuzzy closed mapping in intuitionistic fuzzy topological spaces. Joung Kon Jeon, Young Bae Jun and Jin Han Park (2005) have introduced the notion of intuitionistic fuzzy pre open mappings, intuitionistic fuzzy α open mappings in intuitionistic fuzzy topological spaces. Santhi and Jayanthi (2010) introduced the concept of intuitionistic fuzzy generalized semipre closed mappings. Santhi and Sakthivel (2010) have introduced α generalized closed mappings in intuitionistic fuzzy topological spaces. Arun prakash and Santhi (2012) have introduced intuitionistic fuzzy semi-generalized closed mappings.

Santhi and Sakthivel (2011b) have introduced intuitionistic fuzzy alpha generalized homeomorphism and intuitionistic fuzzy M-alpha generalized homeomorphism in intuitionistic fuzzy topological spaces. Intuitionistic fuzzy C_5-connectedness is introduced by Coker (1997). Ozeag and Coker (1998) have introduced connectedness in intuitionistic fuzzy topological spaces. The several types of fuzzy connectedness in intuitionistic fuzzy topological spaces were introduced by Turnali and Coker (2000). They also investigated some interrelations between these connectedness together with the preservation properties under fuzzy continuous functions. Hazra, Mandal, and Samanta (2003) have introduced connectedness in topology of intuitionistic fuzzy sets. Yong Chan Kim and Abbas (2005) have investigated connectedness in

intuitionistic fuzzy topological spaces. Thakur and Rekha Chadhurvedhi (2006) have introduced intuitionistic fuzzy GO connectedness. The notion of generalized intuitionistic fuzzy connected spaces is introduced by Dhavaseelan (2010). The concepts of intuitionistic fuzzy alpha generalized connectedness were introduced by Santhi and Sakthivel (2011a).

1. GENERAL TOPOLOGY

[Bourbaki, 1966]

In this book, important classes of topological spaces are studied, uniform structures are introduced and applied to topological groups. Real numbers are constructed and their properties are established.

2. MORE ON γ-GENERALIZED CLOSED SETS IN TOPOLOGY

[Maghrabi, 2013]

In this article, the author has introduced and studied a new class of sets called γ generalized regular weakly closed set. It has been proved that the new classes of sets lie between the class of regular weakly closed sets and the class of γ generalized closed sets.

3. ON GENERALIZED b-CLOSED SETS

[Ahmad Al-Omari and Mohammed Salmi Md. Noorani, 2009a]

In this article, the authors have studied the class of generalized b-closed sets and used this notion to consider a new weak and strong form of continuities associated with these sets.

4. FUZZY SETS

[Zadeh, 1965]

In this article, the author has introduced a new type of sets namely fuzzy sets which are characterized by a membership function which assigns to each

object a grade of membership ranging between zero and one. Further the author has provided the notions of inclusion, union, intersection, complement, etc., with respect to the fuzzy sets.

5. FUZZY TOPOLOGICAL SPACES

[Chang, 1968]

In this article, the author has introduced fuzzy topological spaces. This concept is considered to be the generalization of general topological spaces. In brief, the basic concepts such as fuzzy open set, fuzzy closed set, fuzzy neighbourhood, fuzzy continuity etc., are discussed in depth.

6. ON FUZZY b-NEIGHBOURHOODS AND FUZZY b-MAPPINGS IN FUZZY TOPOLOGICAL SPACES

[Benchalli and Jenifer Karnel, 2010b]

In this article, the authors have introduced the concept of fuzzy b-neighbourhood and fuzzy b-continuous mappings in fuzzy topological spaces. The interrelationship of fuzzy b-continuous mappings with various fuzzy mappings is investigated.

7. FUZZY b-GENERALIZED HOMEOMORPHISM IN FUZZY TOPOLOGICAL SPACES

[Benchalli, Jenifer Karnel and Siddapur, 2012]

In this article, the authors have introduced the concept of fuzzy b-generalized homeomorphism, fuzzy b-g^* homeomorphism, contra fuzzy b-continuous mappings and contra fuzzy b-closed mappings in fuzzy topological spaces.

8. FUZZY GENERALIZED ALPHA CLOSED SET AND ITS APPLICATIONS

[Bayaz Daraby and Nimse, 2007]

In this article they have defined and studied fuzzy generalized alpha closed sets, r open sets, fuzzy alpha continuous functions and their applications.

9. FUZZY GENERALIZED γ CLOSED SET IN FUZZY TOPOLOGICAL SPACE

[Dipankar, 2014]

In this article, the author has introduced and studied the concepts of fuzzy generalized γ closed sets and their basic properties in fuzzy topological spaces. Moreover, he has defined fuzzy γ $T_{1/2}$ space in which every fuzzy generalized γ continuous is fuzzy γ continuous. In addition, the author has also introduced and studied fuzzy generalized γ connectedness.

10. γ CONNECTEDNESS IN FUZZY TOPOLOGICAL SPACES

[Hanafy, 2003]

In this paper, the author has introduced the concept of γ connectedness in fuzzy topological spaces. And also author has investigated the interrelations between this type of fuzzy connectedness together with the preservation properties under some types of fuzzy continuity.

11. INTUITIONISTIC FUZZY SETS

[Atanassov, 1986]

In this article, the author has provided the notion of intuitionistic fuzzy sets. This is considered to be the generalization on fuzzy sets. The highlight of this particular article is that some relations and operations concerning classical sets are extended to intuitionistic fuzzy sets.

12. AN INTRODUCTION TO INTUITIONISTIC FUZZY TOPOLOGICAL SPACES

[Coker, 1997]

In this article, the author has introduced intuitionistic fuzzy topological spaces. The notions of intuitionistic fuzzy interior and intuitionistic fuzzy closure are being provided and this is followed by the discussion of some important properties concerning them. Furthermore, the notion of intuitionistic fuzzy continuity is provided.

13. ON FUZZY CONTINUITY IN INTUITIONISTIC FUZZY TOPOLOGICAL SPACES

[Gurcay, Coker and Haydar, 1997]

This article consists of the notions of intuitionistic fuzzy semi open sets, intuitionistic fuzzy pre open sets, intuitionistic fuzzy α-open sets and their corresponding closed sets. Further the relationship between these sets are established.

14. MORE ON INTUITIONISTIC FUZZY SETS

[Atanassov, 1989]

In this article, the author has analyzed some new results on intuitionistic fuzzy sets. Two new operators on intuitionistic fuzzy sets are defined and their basic properties are studied.

15. INTUITIONISTIC FUZZY ALPHA CONTINUITY AND INTUITIONISTIC FUZZY PRECONTINUITY

[Joung Kon Jeon, Young Bae Jun and Jin Han Park, 2005]

In this article, the authors have introduced intuitionistic fuzzy alpha contuinuity and intuitionistic fuzzy pre contuinuity and discussed the relationship between the newly introduced continuous mappings with some of the previously defined intuitionistic fuzzy continuous mappings.

16. INTUITIONISTIC FUZZY SEMIPRE OPEN SETS AND INTUITIONISTIC FUZZY SEMIPRE CONTINUOUS MAPPINGS

[Young Bae Jun and Seok – Zun Song, 2005]

This article consists of the notion of intuitionistic fuzzy semipre open sets and its corresponding closed sets. The properties regarding the union and intersection of these sets are portrayed. Also, the relationship between this new class of sets and some of the previously existing sets are discussed.

17. INTUITIONISTIC FUZZY IRRESOLUTE AND CONTINUOUS MAPPINGS

[Jun, Kang and Song, 2005]

In this article, the notions of intuitionistic fuzzy irresolute mappings, intuitionistic fuzzy pre semi open mappings, intuitionistic fuzzy almost open mappings and intuitionistic fuzzy weakly continuous mappings are introduced, and their relations are investigated. A characterization of intuitionistic fuzzy irresolute mapping is also given.

18. GENERALIZED CONTINUITY IN INTUITIONISTIC FUZZY TOPOLOGY

[Thakur and Rekha Chaturvedi, 2006]

In this paper, the authors have discussed and studied the concept of intuitionistic fuzzy generalized continuous mappings in intuitionistic fuzzy topological spaces. They have analyzed some of their properties and obtained some interesting theorems.

19. INTUITIONISTIC FUZZY CONTRA STRONG PRE CONTINUITY

[Krsteska and Ekici, 2007]

This article consists of the notion of intuitionistic fuzzy contra strong pre continuity. Additionally the authors have presented the notions of intuitionistic fuzzy contra continuous mapping, intuitionistic fuzzy contra pre continuous mapping, intuitionistic fuzzy contra alpha continuous mapping.

20. NOWHERE DENSE SETS IN INTUITIONISTIC FUZZY TOPOLOGICAL SPACES

[Thakur and Dhavaseelan, 2015]

In this article the authors have introduced the concept of nowhere dense sets and investigated the characterizations of intuitionistic fuzzy nowhere dense sets.

21. COMPLETELY CONTINUOUS FUNCTIONS IN INTUITIONISTIC FUZZY TOPOLOGICAL SPACES

[Hanafy and El-Arish, 2003]

In this paper, after giving the basic results related to the product of functions and the graph of functions in intuitionistic fuzzy topological spaces, the authors have introduced and studied the concept of fuzzy completely continuous functions in intuitionistic fuzzy topological spaces.

22. THE CATEGORY OF INTUITIONISTIC FUZZY TOPOLOGICAL SPACES

[Seok Jong Lee and Eun Pyo Lee, 2000]

In this paper, the authors have introduced the concept of intuitionistic fuzzy neighbourhoods. They have investigated the properties of intuitionistic fuzzy continuous mappings, intuitionistic fuzzy open mappings and intuitionistic fuzzy closed mappings in intuitionistic fuzzy topological spaces.

23. ALPHA GENERALIZED HOMEOMORPHISM IN INTUITIONISTIC FUZZY TOPOLOGICAL SPACES

[Santhi and Sakthivel, 2011b]

In this paper, the authors have introduced intuitionistic fuzzy alpha generalized homeomorphism and intuitionistic fuzzy M-alpha generalized homeomorphism in intuitionistic fuzzy topological spaces. They were related to

the fundamental concept of intuitionistic fuzzy continuous mappings and intuitionistic fuzzy open mappings.

24. ALPHA GENERALIZED CLOSED MAPPINGS IN INTUITIONISTIC FUZZY TOPOLOGICAL SPACES

[Santhi and Sakthivel, 2010]

In this article, the authors have introduced the concept of intuitionistic fuzzy alpha generalized closed maps and intuitionistic fuzzy alpha generalized open maps. Some of their properties are investigated.

25. ON GENERALIZED SEMI HOMEOMORPHISM IN INTUITIONISTIC FUZZY TOPOLOGICAL SPACES

[Sakthivel, 2012]

In this article, the author has introduced the concept of intuitionistic fuzzy generalized semi closed mappings, intuitionistic fuzzy generalized semi homeomorphism and intuitionistic fuzzy M-generalized semi homeomorphism in intuitionistic fuzzy topological spaces. Some characterizations of intuitionistic fuzzy generalized homeomorphisms are also provided in this paper.

26. ON CONNECTEDNESS IN INTUITIONISTIC FUZZY TOPOLOGICAL SPACES

[Ozcag and Coker, 1998]

This article consists of the basic concepts related to connectedness in intuitionistic fuzzy topological spaces. They have introduced the concepts of C_5 connectedness, C_S connectedness, C_M connectedness, strong connectedness, super connectedness, C_i connectedness (i=1,2,3,4) and obtained several preservation properties and some characterizations concerning connectedness in these spaces.

Notations

IFS	-	Intuitionistic fuzzy set
IFSs	-	Intuitionistic fuzzy sets
IFT	-	Intuitionistic fuzzy topology
IFTS	-	Intuitionistic fuzzy topological space
A^c	-	The complement of A
int(A)	-	Interior of A
cl(A)	-	Closure of A
IFC(X)	-	The family of all intuitionistic fuzzy closed sets of X
IFSC(X)	-	The family of all intuitionistic fuzzy semi closed sets of X
IFPC(X)	-	The family of all intuitionistic fuzzy pre closed sets of X
IFαC(X)	-	The family of all intuitionistic fuzzy α closed sets of X
IFRC(X)	-	The family of all intuitionistic fuzzy regular closed sets of X
IFγC(X)	-	The family of all intuitionistic fuzzy γ closed sets of X
IFγGC(X)	-	The family of all intuitionistic fuzzy γ generalized closed sets of X
IFO(X)	-	The family of all intuitionistic fuzzy open sets of X
IFSO(X)	-	The family of all intuitionistic fuzzy semi open sets of X
IFPO(X)	-	The family of all intuitionistic fuzzy pre open sets of X
IFαO(X)	-	The family of all intuitionistic fuzzy α open sets of X
IFRO(X)	-	The family of all intuitionistic fuzzy regular open sets of X
IFγO(X)	-	The family of all intuitionistic fuzzy γ open sets of X
IFγGO(X)	-	The family of all γ generalized open sets of X
IFγGCSs	-	Intuitionistic fuzzy intuitionistic fuzzy γ generalized closed sets
IFγGOSs	-	Intuitionistic fuzzy intuitionistic fuzzy γ generalized open sets