REVIEW OF LITERATURE

One of the most attractive features of fuzzy set theory is that it provides a mathematical setting for the integration of subjective categories represented by membership functions. Intuitionistic fuzzy sets are an extension of fuzzy sets in which not only a membership degree is given, but also a non-membership degree, which is more or less independent is provided. Considering the growing interest in intuitionistic fuzzy sets, it is useful to determine the applications of intuitionistic fuzzy set theory in the framework of the different fields such as decision making, quantitative analysis, information processing etc. With the demand for knowledge-handling systems capable of dealing with and distinguishing between various facts of imprecision, a clear and formal characterization of the mathematical models implementing such analysis is essential and are carried out by the use of fuzzy graphs and intuitionistic fuzzy graphs.

Fuzzy sets

Lofti Zadeh (1965) introduced fuzzy sets as a class of objects with a continuum of grades of membership. Such a set is characterized by a membership (characteristic) function which assigns to each object a grade of membership ranging between zero and one. The notions of inclusion, union, intersection, complement, relation, convexity, etc., are extended to such sets, and various properties of these notions in the context of fuzzy sets are established. In particular, a separation theorem for convex fuzzy sets is proved without requiring that the fuzzy sets be disjoint.

Joseph Brown (1971) defined fuzzy sets as mappings from sets into Boolean lattices. The basic set theory type results for Zadeh's fuzzy sets are shown to carry over. Some results on convex fuzzy sets, star-shaped fuzzy sets, arc wise connected fuzzy sets, fuzzy sets with “holes”, bounded fuzzy sets, and connected fuzzy sets are discussed.
De Luca and Termini (1972) introduced some new algebraic properties on the class \( L(I) \) of the “fuzzy sets”. In particular the generalized characteristic function furnished with the lattice operations proposed by Zadeh is a Brouwerian lattice. The possibility of inducing other different lattice operations to the whole class \( L(I) \) or to a suitable subclass of it where considered. The problem of the relationship between fuzzy sets and classical set theory where analyzed.

The concept of fuzzy sets of type 2 defined by Zadeh is an extension of ordinary fuzzy sets. The fuzzy set of type 2 can be characterized by a fuzzy membership function the grade (or fuzzy grade) of which is a fuzzy set in the unit interval \([0, 1]\) rather than a point in \([0, 1]\). Masaharu Mizumoto and Kokichi Tanaka (1976) investigated the algebraic structures of fuzzy grades under the operations of join, meet, and negation which are defined by using the extension principle, and shows that convex fuzzy grades form a commutative semiring and normal convex fuzzy grades form a distributive lattice under join and meet. Moreover, the algebraic properties of fuzzy grades under the operations ‘\( \cup \)’ and ‘\( \cap \)’ which are slightly different from join and meet respectively, are briefly discussed.

Loffi Zadeh (1978) considered fuzzy sets as a basis for a theory of possibility. The theory of possibility described is related to the theory of fuzzy sets by defining the concept of a possibility distribution as a fuzzy restriction which acts as an elastic constraint on the values that may be assigned to a variable.

Dubois and Prade (1985) made a review of fuzzy set aggregation connectives which provides an extensive survey on fuzzy set-theoretic operations, and emphasized the relevance of the theory of functional equations in the axiomatical construction of classes of such operations and the derivation of functional representations. The second part is devoted to the application of fuzzy set theory to multifactorial evaluation. Some links between this approach and multiattribute utility theory where explored.
Intuitionistic fuzzy sets and its applications

Krassimir Atanassov (1986) defined the concept ‘intuitionistic fuzzy set’ (IFS) as a generalization of the concept ‘fuzzy set’. Various properties are proved, which are connected to the operations and relations over sets, and with modal and topological operators, defined over the set of IFS’s. Krassimir Atanassov (1989) introduced new results on intuitionistic fuzzy sets. Two news operators- modal operator and topological operator on intuitionistic fuzzy sets are defined and their basic properties are studied. Again Krassimir Atanassov (1992) gave remarks on the intuitionistic fuzzy sets, in which the question of the relation between some intuitionistic fuzzy set (IFS) $A$ and the universe $F$ which is a universe of the IFS $E$ where the latter is a universe of $A$, where discussed. Krassimir Atanassov (1994) defined four new operations ($@$, $\$, $#$ and *) along with the existing operations ($\cup$, $\cap$, $+$ and $.$) over the intuitionistic fuzzy sets and some of their basic properties where discussed. Later Krassimir Atanassov (1996) proved equality between intuitionistic fuzzy sets. It is proved that for every two intuitionistic fuzzy sets $A$ and $B$: $((A \cap B) \cup (A \cup B)) \@ ((A \cap B) \cdot (A \cup B)) = A \@ B$.

Using the definition of intuitionistic fuzzy sets by Krassimir Atanassov and vague sets by Gau and Byehrer, Bustince and Burillo (1996) analyzed the connection and coincidence between them. Krassimir Atanassov and George Gargov (1998) defined intuitionistic fuzzy set based on the definition of intuitionistic fuzzy logics of different kinds. They constructed two versions of intuitionistic fuzzy propositional calculus (IFPC) and a version of intuitionistic fuzzy predicate logic (IFPL). Krassimir Atanassov (2000) formulated two theorems related to the relations between some of the operators, defined over the intuitionistic fuzzy sets where proved.

Supriya Kumar et al. (2000) defined concentration, dilation and normalization of intuitionistic fuzzy sets. These definitions will be useful while dealing with various linguistic hedges like “very”, “more or less”, “highly”, “very very” etc. involved in the problems under intuitionistic fuzzy environment.
Eulalia Szmidt and Janusz Kacprzyk (2000) proposed a geometrical representation of an intuitionistic fuzzy set is to find distances between intuitionistic fuzzy sets. New definitions are introduced and compared with the approach used for fuzzy sets. It is shown that all three parameters describing intuitionistic fuzzy sets should be taken into account while calculating those distances.

Glad Deschrijver and Etienne Kerre (2003) gave the relationship between some extensions of fuzzy set theory. The summery of links that exist between fuzzy sets and other mathematical models are given. Chris Cornelis et al. (2004) considered implication in intuitionistic fuzzy and interval-valued fuzzy set theory: construction, classification, application. Also the intuitionistic ideas are redefined giving rise to both approaches as models of imprecision and applied in a practical context. Glad Deschrijver and Etienne Kerre (2007) discussed the mathematical relationship between intuitionistic fuzzy sets and other models of imprecision.

Intuitionistic fuzzy sets have been applied in various situations dealing with uncertainty such as decision making, artificial intelligence etc. A few articles dealing on application of intuitionistic fuzzy sets are reviewed below. Plamen Angelov (1997) proposed a new concept of the optimization problem under uncertainty. It is an extension of fuzzy optimization in which the degrees of rejection of objective(s) and constraints are considered together with the degrees of satisfaction. This approach is an application of the intuitionistic fuzzy (IF) set concept to optimization problems. An approach to solve such problems is proposed and illustrated with a simple numerical example. It converts the introduced intuitionistic fuzzy optimization (IFO) problem into the crisp (non-fuzzy) one. The advantage of the IFO problems is twofold: they give the richest apparatus for formulation of optimization problems and, on the other hand, the solution of IFO problems can satisfy the objective(s) with bigger degree than the analogous fuzzy optimization problem and the crisp one.
Supriya Kumar et al. (2001) studied the Sanchez's approach for medical diagnosis and extended this concept with the notion of intuitionistic fuzzy set theory which is a generalization of fuzzy set theory.

Deng-Feng Li (2005) multi-attribute decision making using intuitionistic fuzzy sets is investigated, in which multiple criteria are explicitly considered, several linear programming models are constructed to generate optimal weights for attributes, and the corresponding decision-making methods have also been proposed. Feasibility and effectiveness of the proposed method are illustrated using a numerical example.

Krassimir Atanassov et al. (2005) discussed intuitionistic fuzzy interpretations of the processes of multi-person and of multi-measurement tool multi-criteria decision making.

Ming-Hung Shu et al. (2006) used intuitionistic fuzzy sets for fault-tree analysis on printed circuit board assembly. An algorithm of the intuitionistic fuzzy fault-tree analysis is proposed in this paper to calculate fault interval of system components and to find the most critical system component for the managerial decision-making based on some basic definitions. The proposed method is applied for the failure analysis problem of printed circuit board assembly. Deng-Feng Li (2008) gave a note on using intuitionistic fuzzy sets for fault-tree analysis on printed circuit board assembly.

Hua-Wen Liu and Guo-Jun Wang (2007) presented new methods for solving multi-criteria decision-making problem in an intuitionistic fuzzy environment. The concept of intuitionistic fuzzy point operators are introduced and discussed. By using the intuitionistic fuzzy point operators, the degree of uncertainty of the elements in a universe corresponding to an intuitionistic fuzzy set are reduced. Furthermore, a series of new score functions are defined for multi-criteria decision-making problem based on the intuitionistic fuzzy point operators and the evaluation function and their effectiveness and advantage are illustrated by examples.
Zeshui Xu (2007) defined the concepts of intuitionistic preference relation, consistent intuitionistic preference relation, incomplete intuitionistic preference relation and acceptable intuitionistic preference relation, and studied their various properties. An approach to group decision making based on intuitionistic preference relations and an approach to group decision making based on incomplete intuitionistic preference relations respectively is developed, in which the intuitionistic fuzzy arithmetic averaging operator and intuitionistic fuzzy weighted arithmetic averaging operator are used to aggregate intuitionistic preference information, and the score function and accuracy function are applied to the ranking and selection of alternatives. Finally, a practical example is provided to illustrate the developed approaches.

Zeshui Xu and Ronald Yager (2007) investigated the dynamic multi-attribute decision making problems with intuitionistic fuzzy information. The notions of intuitionistic fuzzy variable and uncertain intuitionistic fuzzy variable are defined, and two new aggregation operators: dynamic intuitionistic fuzzy weighted averaging operator and uncertain dynamic intuitionistic fuzzy weighted averaging operator are presented.

Ludmila Dymova and Pavel Sevastjanov (2010) presented an interpretation of intuitionistic fuzzy sets in terms of evidence theory: Decision making aspect. This interpretation makes it possible to represent all mathematical operations on intuitionistic fuzzy values as the operations on intervals. The usefulness of the developed method is illustrated with the known example of multiple criteria decision making problem.

Zeshui Xu and Hui Hu (2010) investigated the intuitionistic fuzzy multiple attribute decision-making problems where the attribute values are expressed in intuitionistic fuzzy numbers or interval-valued intuitionistic fuzzy numbers. Some notions, such as intuitionistic fuzzy ideal point, interval-valued intuitionistic fuzzy ideal point, the modules of intuitionistic fuzzy numbers, and interval-valued intuitionistic fuzzy numbers are introduced.
Zhiping Chen and Wei Yang (2012) gave a new multiple criteria decision making method based on intuitionistic fuzzy information. Ejegwa et al. (2014) reviewed the concept of intuitionistic fuzzy set and proposed its application in career determination using normalized Euclidean distance method of measuring the distance between each student and career respectively. Solution is obtained by looking for the smallest distance between each student and each career.

Fuzzy Graphs and its applications

Kaufmann (1973) gave the first definition of fuzzy graphs based on Zadeh’s fuzzy relation. Bhattacharya (1987) shows that fuzzy group can be associated with a fuzzy graph in a natural way. Some properties of fuzzy graphs are considered and the notions of eccentricity and center are introduced. Our examples indicate that results from (crisp) graph theory do not always have analogs for fuzzy graphs.

Mordeson and Peng Chang-Shyh (1994) defined the operations of Cartesian product, composition, union, and join on fuzzy subgraphs of graphs $G_1$ and $G_2$. If the graph $G$ is formed from $G_1$ and $G_2$ by one of these operations, the necessary and sufficient conditions for an arbitrary fuzzy subgraph of $G$ also to be formed by the same operation from fuzzy subgraphs of $G_1$ and $G_2$ is determined.

Mordeson and Premchand Nair (1996) show that if the fuzzy graph $(\sigma, \mu)$ is a cycle, then it is a fuzzy cycle if and only if $(\sigma, \mu)$ is not a fuzzy tree. The relationship between fuzzy bridges and cycles are examined. The concepts of fuzzy cycle rank and fuzzy co-cycle rank for fuzzy graphs are introduced.

Somasundaram A and Somasundaram S (1998) introduced the concepts of domination and total domination in fuzzy graphs. They determined the domination number $\gamma$ and the total domination number $\gamma_t$ for several classes of fuzzy graphs and obtain bounds for the same.
Sunitha and Vijayakumar (1999) studied some properties of fuzzy bridges and fuzzy cutnodes. A characterization of fuzzy trees is obtained using these concepts.

Kiran Bhutani and Azriel Rosenfeld (2003) studied about strong arcs in fuzzy graphs. According to them an arc of a fuzzy graph is called strong if its weight is at least as great as the strength of connectedness of its end nodes when it is deleted. An arc is strong iff its weight is equal to the strength of connectedness of its end nodes. A bridge is strong, but a strong arc need not be a bridge. An arc of maximum weight is strong, but a strong arc need not have maximum weight. In a connected graph, there is a strong path (a path consisting of strong arcs) between any two nodes. A fuzzy graph is a fuzzy tree iff there is a unique strong path between any two of its nodes. In a fuzzy tree, an arc is strong iff it is a bridge, and a strong path between two nodes is a path of maximum strength between them.

Kiran Bhutani and Rosenfeld (2003, a) defined fuzzy end node in a fuzzy graph, and showed that no node can be both a cut node and a fuzzy end node. In a fuzzy tree, every node is either a cut node or a fuzzy end node, but the converse is not true. They also showed that any nontrivial fuzzy tree has at least two fuzzy end nodes, and we characterize fuzzy cycles that have no cut nodes or no fuzzy end nodes.

Tomaz Savsek et al. (2006) studied on fuzzy trees in decision support systems based on the assumption that there exists a fuzzy tree structure and a distance between fuzzy trees which provides the basis for fuzzy decision-making. A new definition of the fuzzy relational tree structure, the development of a new comparative method for fuzzy trees and its experimental testing and evaluation, a new descriptive method of military structures in a fuzzy tree format and the development of a fuzzy decision support system are proposed.
Nagoor Gani and Radha (2008) introduced regular fuzzy graphs, total degree and totally regular fuzzy graphs. Necessary and sufficient conditions for regular fuzzy graphs are provided.

Sunil Mathew and Sunitha (2009) studied on types of arcs in a fuzzy graph. The concept of connectivity plays an important role in both theory and applications of fuzzy graphs. Depending on the strength of an arc, arcs of a fuzzy graph are classified into three types namely $\alpha$-strong, $\beta$-strong and $\delta$-arcs. The advantage of this type of classification is that it helps in understanding the basic structure of a fuzzy graph completely. The relation between strong paths and strongest paths in a fuzzy graph are analyzed and characterizations for fuzzy bridges, fuzzy trees and fuzzy cycles using the concept of $\alpha$-strong, $\beta$-strong and $\delta$-arcs are obtained. An arc of a fuzzy tree is $\alpha$-strong if and only if it is an arc of its unique maximum spanning tree. Also different types of arcs in complete fuzzy graphs are identified.

Al-Hawary (2011) defined new operations on fuzzy graphs; namely direct product, semi-strong product and strong product. Further the author introduced the concept of balanced fuzzy graph and also obtained the necessary and sufficient conditions for products of two fuzzy balanced graphs to be balanced. Al-Hawary and Bayan Horani (2016) investigated the notions of balanced and co-balanced product fuzzy graphs and defined several new operations on product fuzzy graphs. Al-Hawary (2017) provided two operations namely parallel connections and series connections on fuzzy graphs. Using these operations the notions of balanced fuzzy graphs, strong and complete fuzzy graphs are studied.

Muhammad Akram (2011) introduced the notion of bipolar fuzzy graphs, described various methods of their construction, discussed the concept of isomorphisms of these graphs, and investigated some of their important properties. The notion of strong bipolar fuzzy graphs is introduced and some of their properties are studied. Some propositions of self
complementary and self weak complementary strong bipolar fuzzy graphs are studied.

Muhammad Akram (2013) investigated the concepts of neighbourly irregular bipolar fuzzy graphs, neighbourly totally irregular bipolar fuzzy graphs, highly irregular bipolar fuzzy graphs and highly totally irregular bipolar fuzzy graphs. A necessary and sufficient condition under which neighbourly irregular and highly irregular bipolar fuzzy graphs are equivalent is discussed. The notion of bipolar fuzzy digraphs is introduced. The bipolar fuzzy influence graph of a social group is also described.

Mini Tom and Sunitha (2013) studied on strongest paths, delta arcs and blocks in fuzzy graphs. A necessary and sufficient condition for an arc in a fuzzy graph to be a strongest path and a sufficient condition for a path in a fuzzy graph to be a strongest path are obtained. A characterization of $\delta$-arc and the relationship between fuzzy cutnodes and $\delta$-arcs are obtained. Also a characterization of blocks is obtained using shortest paths.

Manjusha and Sunitha (2015) introduced strong domination in fuzzy graphs using membership values of strong arcs in fuzzy graphs. The strong domination number $\gamma_s$ of complete fuzzy graph and complete bipartite fuzzy graph is determined and bounds are obtained for the strong domination number of fuzzy graphs. Also the relationship between the strong domination number of a fuzzy graph and that of its complement are discussed.

Fuzzy graphs have been applied in various real life situations where fuzzy graph models helps in understanding and solving the problem more precisely. Some articles dealing on application of fuzzy graphs are reviewed below. Sun et al. (1997) explored the possibility of application of the fuzzy graph theory to the evaluation of human cardiac function. The cardiac function of two groups of persons working under special environment where evaluated using the method of fuzzy graph theory.
Senthilraj Swaminathan (2012) considered the problem of scheduling N jobs on a single machine and obtained the minimum value of the job completion time by using fuzzy graph.

Myna (2015) used fuzzy graph model to represent a traffic network of a city and discussed a method to find different types of accidental zones in a traffic flows.

**Intuitionistic fuzzy graphs and its applications**

Shannon and Krassimir Atanassov (1994) gave the first step to the theory of intuitionistic fuzzy graphs (IFGs) using five types of Cartesian products ($\otimes_1$, $\otimes_2$, $\otimes_3$, $\otimes_4$, $\otimes_5$). Shannon and Krassimir Atanassov (2006) discussed a new generalization of the intuitionistic fuzzy graphs, using as a basis the concepts of intuitionistic fuzzy sets, intuitionistic fuzzy relations and index matrices.

Parvathi and Karunambigai (2006) gave a new definition for min-max intuitionistic fuzzy graph. Some properties of intuitionistic fuzzy graphs are analyzed through suitable illustrations. Young Bae Jun (2006) introduced the notion of intuitionistic fuzzy graph association to intuitionistic fuzzy sub (semi) group.

Karunambigai et al. (2007) studied shortest paths in networks by using intuitionistic fuzzy graph method. Shortest paths are one of the simplest and most widely used concepts in networks. More recently, fuzzy graphs, along with generalizations of algorithms for finding optimal paths within them, have emerged as an adequate modeling tool for imprecise systems. Fuzzy shortest paths also have a variety of applications. Here the authors presented a model based on dynamic programming to find the shortest paths in intuitionistic fuzzy graphs.
Thilagavathi et al. (2008) gave an alternative definition for intuitionistic fuzzy graph and intuitionistic fuzzy analogs of several basic fuzzy graph theoretic concepts are introduced.

Parvathi et al. (2009) studied the definition of complement of an intuitionistic fuzzy graph (IFG) and some properties of self-complementary IFGs are shown. The operations on intuitionistic fuzzy graphs such as union, join, cartesian product and composition are defined and some of their properties are also analyzed.

Panagiotis Chountas (2009) discussed an intuitionistic fuzzy version of the special particular case of a graph-the tree, called an intuitionistic fuzzy tree and their index matrix interpretation. Nagoor Gani and Shajitha Begum (2010) examined the properties of various types of degrees, order and size of intuitionistic fuzzy graphs and new definitions for complete intuitionistic fuzzy graph and intuitionistic regular fuzzy graph are given.

Parvathi Rangasamy and Thamizhendhi (2010) introduce cardinality of an intuitionistic fuzzy graph. Also, the definition of bipartite, complete bipartite, strong arc, strength of the connectedness, dominating set, domination number, independent set, independent domination number, total dominating and total domination number in intuitionistic fuzzy graphs are given.

Karunambigai et al. (2011) defined homomorphism, weak isomorphism and co-weak isomorphism of minmax IFGs with suitable illustrations. Some of the properties of isomorphism on IFG and isomorphism on strong IFG are also analyzed.

Karunambigai et al. (2011, a) introduced constant intuitionistic fuzzy graph and totally constant intuitionstic fuzzy graphs. Necessary and sufficient conditions under which they are equivalent is studied. A characterization of constant intuitionistic fuzzy graph on a cycle is given. Parvathi et al. (2011) discussed three examples on the graph operations over intuitionistic fuzzy tree.
Vinoth kumar and Geetha Ramani (2011) introduced product intuitionistic fuzzy graphs and proved several results which are analogous to intuitionistic fuzzy graphs. Properties for product partial intuitionistic fuzzy subgraphs are given.

Muhammad Akram and Bijan Dawaz (2012) introduced the notion of strong intuitionistic fuzzy graphs and investigated some of their properties. Propositions of self complementary and self weak complementary strong intuitionistic fuzzy graphs and the concept of intuitionistic fuzzy line graphs are introduced.

Karunambigai et al. (2012) classified the arcs into $\alpha$-strong, $\beta$-strong and $\delta$-weak, based on its strength. These arcs are used to study the structure of complete intuitionistic fuzzy graph and constant intuitionistic fuzzy graph.

Velammal (2012) introduced the concept of edge domination and total edge domination in intuitionistic fuzzy graphs. The edge domination number and the total edge domination number for several classes of intuitionistic fuzzy graphs are obtained.

Karunambigai et al. (2013) introduced the notion of balanced intuitionistic fuzzy graphs and presented some of their properties.

Muhammad Akram and Wieslaw Dudek (2013, a) studied on intuitionistic fuzzy hypergraphs with applications. Hypergraphs are considered a useful tool for modeling system architectures and data structures and to represent a partition, covering and clustering in the area of circuit design. The concept of intuitionistic fuzzy set theory is applied to generalize results concerning hypergraphs. For each intuitionistic fuzzy structure defined, cut-level sets are used to define an associated sequence of crisp structures. Applications of intuitionistic fuzzy hypergraphs are also presented.

Jahir Hussain and Yahya Mohamed (2014) studied irregular intuitionistic fuzzy graphs. Some results on highly irregular intuitionistic fuzzy
graphs and its complement are established. Also isomorphic properties of μ-busy, ν-busy nodes and μ-free, ν-free nodes in highly irregular intuitionistic fuzzy graphs are discussed.

Jahir Hussain and Yahya Mohamed (2014, a) studied some results of isomorphism on highly irregular intuitionistic fuzzy graphs. Also isomorphism on neighbourly irregular intuitionistic fuzzy graph and its complement are established.

Karunambigai et al. (2014) gave the necessary condition for the Product intuitionistic fuzzy graph to be balanced. Some properties and results on the balancing of the regular and product intuitionistic fuzzy graphs are established.

Muhammad Akram and Alshehri (2014) introduced various types of intuitionistic fuzzy bridges, intuitionistic fuzzy cut vertices, intuitionistic fuzzy cycles, and intuitionistic fuzzy trees in intuitionistic fuzzy graphs and investigated some of their properties.

Karunambigai et al. (2015) gave some properties of a regular intuitionistic fuzzy graph. Particularly, strongly regular, edge regular intuitionistic fuzzy graphs and biregular intuitionistic fuzzy graphs are defined with suitable illustrations and the necessary and sufficient condition for an intuitionistic fuzzy graph to be strongly regular is given and some results on edge and biregular intuitionistic fuzzy graph have been analysed.

Karunambigai et al. (2015, a) some properties of an edge regular intuitionistic fuzzy graph are given and the relationship between degree of a vertex and degree of an edge in intuitionistic fuzzy graph is studied. The condition under which edge regular intuitionistic fuzzy graph and totally edge regular intuitionistic fuzzy graph are equivalent is provided. Also, partially edge regular intuitionistic fuzzy graph and fully edge regular intuitionistic fuzzy graph are introduced with suitable illustrations.
Sankar Sahoo and Madhumangal Pal (2015) define three operations on intuitionistic fuzzy graphs, viz. direct product, semi-strong product and strong product. In addition, many interesting results regarding the operations are investigated. Moreover, it is demonstrated that the products of strong intuitionistic fuzzy graphs are strong intuitionistic fuzzy graphs. Finally, product intuitionistic fuzzy graph is defined and many interesting results are investigated.

Al-Hawary and Bayan Horani (2017) defined the operations of direct product, semi-strong product and strong product on intuitionistic product fuzzy graphs and studied the results related to balanced intuitionistic product fuzzy graphs.

Ismail Mohideen et al. (2016) derived some properties of union and join on regular intuitionistic fuzzy graphs, and theorems related to these concepts are stated and proved.

Application of intuitionistic fuzzy graph was presented by Muhammad Akram et al. (2014). In their paper they presented the intuitionistic fuzzy organizational and neural network models, intuitionistic fuzzy neurons in medical diagnosis, intuitionistic fuzzy digraphs in vulnerability assessment of gas pipeline networks, and intuitionistic fuzzy digraphs in travel time as examples of intuitionistic fuzzy digraphs in decision support system. Also the algorithms for these decision support systems are designed and implemented.