Chapter -2

Introduction to Fuzzy & Intuitionistic Fuzzy Databases
2.1 Introduction

Advances in Computer Science and the recognition of data as a crucial organization resource have led to the rapid progress and development of information systems. Information system, such as Database Management System (DBMS) and Information Storage and Retrieval System (ISRS), involves the management, collection, utilization and dissemination of information. In short, it is a means of furnishing information needed by an organization.

However, existing DBMS can only handle crisp, precise and non-ambiguous data. In other words, these systems do not cater for vague and ambiguous data which are fuzzy in nature - even though much of the human reasoning is based on fuzzy reasoning. In fact, fuzzy data arise constantly in real life from human thought and cognition processes and we often make decision based on them. It should be noted that information is useful only if it can be obtained in an easy and natural manner.
Clearly, as DBMS becomes more important for decision making, the problem of handling fuzzy data, being more compatible with human thought, will become increasingly important. Such a DBMS, if implemented, will improve human-machine interface and broaden the application areas of DBMS. Attempts to build DBMS which is able to represent and manipulate fuzzy data have received the attention of researchers recently. As a result, various models and prototypes have been proposed or implemented DBMS with Uncertainty Handling. The application of fuzzy set theory in DBMS can be classified into two main classes. Class 1 concerns the study of fuzzy query processing in conventional (non-fuzzy) DBMS; Class 2 deals with DBMS which, besides having the ability to store and manipulate fuzzy data directly, also supports fuzzy query.

2.2 Conventional DBMS with Fuzzy Queries

Early DBMS's with uncertainty handling are developed within the framework of non-fuzzy DBMS. Generally, these systems deal with the
construction and evaluation of fuzzy query against a crisp Database, and ignore the problem of direct representation of fuzzy data in DBMS. Many authors like Chang [26], Wong [27], Kacprzyk [28] explore fuzzy queries on classical database but Bosc [29] discuss the extension of the SQL language to handle fuzzy query based on the framework of fuzzy set theory proved to be very efficient than others. In general, under the conventional non-fuzzy DBMS environment, fuzzy query processing based on the theory of fuzzy set is more powerful when compared to those using ad hoc approach or probability theory.

2.3 Fuzzy Databases with Fuzzy Queries

Recent DBMS's with uncertainty handling are more advanced when compared to the earlier ones. They address the problem of direct representation of fuzzy data in the DBMS as well as the construction and evaluations of fuzzy query. Buckles [30-32] propose one of the earliest versions of Fuzzy Relational Database System (FRDBS) by merging the theory of fuzzy set and Relational Database System (RDBS). They
formulate a robust theoretical framework of similarity-based FRDBS which has the following properties:

1. It allows non-atomic tuple components.
2. It requires similarity relation for each domain set of data in order to preserve important properties of classical RDBS.
3. It accepts user-defined threshold of acceptance during query evaluation.
4. It only supports a specific class of fuzzy number but does not support Possibility Distribution data type. Shenoi [33-35] generalizes the similarity-based model. They observe that the preservation of the properties of classical RDBS above can also be done by restricting the components of fuzzy tuples to be non-empty subsets of equivalence classes from domain partitions.

Since the notion of equivalence classes is more general than the notion of similarity relation, an equivalence model of FRDBS, which is a generalization of similarity based model, has been proposed. Another different approach in the representation and manipulation of fuzzy data is advanced by Umano [36] who develops Freedom-0, a FRDBS. Unlike the
model by Buckle and Shenoi which limits the fuzzy data to specific fuzzy number, Freedom-0 allows for both possibility distribution and Fuzzy number. However, even though Freedom-0 is more powerful in terms of its fuzzy data structure, it lacks the formal Database framework which is found in the models of Buckle. Freedom-0 uses an embedded programming language in Fortran for fuzzy data manipulation can handle fuzzy query.

Generally speaking, the FRDBS's mentioned above demonstrate the following major advantages over the conventional RDBS model.

1. It allows a more natural way of handling data because fuzzy data are more compatible with human thoughts and cognitions.

2. The use of fuzzy set and possibility distribution theory provides a formal mathematics foundation for the systematic representation and manipulation of crisp and fuzzy data.

3. It provides a Database environment to handle both crisp and fuzzy data. However, in this model, there is no doubt that RDBS is the key Database framework in fuzzy data handling.
2.4 Intuitionistic Fuzzy Database

As an intuitionistic fuzzy set is a generalization of fuzzy set, Buckles and Petry defined fuzzy database as a generalization of classical database. There model is based on similarity relation for each domain of fuzzy database. A fuzzy relational database is defined as set of relations where each relation is a set of tuple. If \( t_i \) represent the \( i \)-th tuple it has form \((d_{i1}, d_{i2}, \ldots, d_{im})\). In a classical relational database each component \( d_{ij} \) of the tuple is an element of the corresponding scalar domain \( D_j \) i.e. \( d_{ij} \) belongs to \( D_j \). But in case of fuzzy relational database, the element of the tuple consists of either singleton or crisp subset of the scalar domain.

Shenoi and Melton generalizes the model by allowing fuzzy proximity relation in each domain in place of fuzzy equivalence relation.

Further the generalization of fuzzy database that is an intuitionistic fuzzy database introduced by Supriya, Biswas and roy [14]. They incorporate an intuitionistic fuzzy tolerance intuitionistic fuzzy in place of fuzzy proximity relation. The reason behind such generalization lies in the fact that there is always a fair chance of the existence of some in deterministic
part while evaluating relation between two elements of a domain in database. Fuzzy database could not define this in deterministic part so we need intuitionistic fuzzy database to deal with it.

A more detailed discussion on intuitionistic fuzzy database can be seen in paper of S.K. de, R. Biswas and A.R. Roy [14].

**Definition 1:**

An intuitionistic fuzzy database is a set of relation where each pair of such relation \( R \) is a subset of the cross product:

\[
2^{D_1} \times 2^{D_2} \times \ldots \times 2^{D_m}
\]

Where \( 2^{D_i} = P(D_i) - \emptyset \), and \( P(D_i) \) is the power set of \( D_i \), here \( R \) is called the intuitionistic fuzzy database relation.

**Definition 2:**

Let \( R \subseteq 2^{D_1} \times 2^{D_2} \times \ldots \times 2^{D_m} \) be an intuitionistic fuzzy database relation. An intuitionistic fuzzy tuple (with respect to \( R \)) is an element \( t_i(d_{i1}, d_{i2} \ldots \ldots d_{im}) \) of \( R \). For each domain \( D_j \), if \( T \) be an intuitionistic fuzzy tolerance relation then the membership function given by:
\[ \mu_r : D_j \times D_j \rightarrow [0,1] \]

And the non membership function is given by

\[ \nu_r : D_j \times D_j \rightarrow [0,1] \]

satisfying Atanassov condition.

2.5 Conclusion:

As we know that classical database is not sufficient to deal with imprecise data so there is a need of database system that can handle vague and imprecise data. This need is fulfilled by Fuzzy and intuitionistic fuzzy database. As fuzzy database is not sufficient to deal with in deterministic part of relations we introduced IF Database. In this chapter we study about DBMS, the need of fuzzy database, classical database with fuzzy queries, fuzzy database working with fuzzy queries and Intuitionistic fuzzy database along with its definition.