CHAPTER I

PRELIMINARIES

1.1 INTRODUCTION

In the problem of decision making when more and more decision-makers participate in the process of decision-making, which is termed as Multiple - Attribute Group Decision Making (MAGDM), there is complexity and uncertainty of the situations and vagueness of data. Also in this process the information of the attributes weights could not be given distinctly and the values of the attributes are not the real numbers but the interval numbers. The decision-makers in uncertain multiple-attribute group decision utilize the interval numbers as the evaluating languages, which show no distinct preference information. So it is one of the key problem to deal with the interval numbers. Excellent projects are easily chosen to use in decision making based on the handled information of the interval numbers, and this is called as Fuzzy Multiple - Attribute Group Decision Making (FMAGDM).

Atanassov [1986, 1989], and Atanassov & Gargov [1989] introduced the concept of intuitionistic fuzzy sets (IFS) and interval valued intuitionistic fuzzy sets (IVIFS). In statistical analysis, the correlation coefficient plays an important role in measuring the strength of the linear relationship between two variables or alternatives. Gerstenkorn & Manko [1991] discussed the correlation of Intuitionistic fuzzy sets in a finite space. Yu [1993] extended in the case of infinite sets. Hong & Hwang [1995] discussed the correlation coefficient of Intuitionistic fuzzy sets in probability spaces and gave the correct forms of Yu's results. Bustince & Burillo [1995] introduced the correlation coefficient of interval-valued intuitionistic fuzzy sets. Wang & Li [1989] proposed the correlation coefficient of interval-valued intuitionistic fuzzy numbers. The works of Chiang & Lin [1999], Hung & Wu [2001, 2002], Liu & Kao [2002] and Mitchell [2004], towards the literature of Fuzzy correlation can be mentioned. Zeng & Li [2007] proposed a new method of correlation coefficient for Intuitionistic fuzzy sets.

Park et.al., [2009] introduced the correlation coefficient of interval valued intuitionistic fuzzy sets in the context of score functions which will be used as the ranking tool in this research work.

This research work proposes new algorithms for MAGDM problems under interval valued intuitionistic fuzzy environment together with variety of attributes weight determining methods. Sometimes in decision making problems the weights of the attributes may be known, partially known or completely unknown. In these situations it becomes necessary to relieve the decision makers tendency to be biased towards some selected attributes. In this work we proposed some attribute weight determining methods which would present a consensus for the decision makers especially in situations when the weights are completely unknown.

Atanassov [1986] explained that a definition of the concept 'intuitionistic fuzzy set' (IFS), the latter being a generalization of the concept 'fuzzy set'. Also, 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. Atanassov [1989] discussed that new results on intuitionistic fuzzy sets, the basic properties of two operators on intuitionistic fuzzy sets are defined and their basic properties are studied.

Atanassov [1994] analyzed that the different operators which are defined over the interval valued intuitionistic fuzzy sets and their basic properties.

Atanassov and Gargov [1989] studied that a generalization of the notion of a intuitionistic fuzzy set is given in the spirit of the ordinary interval valued fuzzy sets. The new notion is called the interval valued intuitionistic fuzzy set (IVIFS).

Bustince and Burillo [1995] obtained that with respect to multi-attribute group decision making with interval-valued intuitionistic uncertain linguistic information, correlation and correlation coefficient. To obtain the optimal weight vector, models based on the introduced correlation coefficient were constructed. Furthermore, two aggregation operators called the interval-valued intuitionistic uncertain linguistic Shapley averaging operator and the interval-valued intuitionistic uncertain linguistic Shapley geometric operator are defined, which were used to aggregate the interval-valued intuitionistic uncertain linguistic information. Moreover, an approach to multi attribute group decision-making under interval-valued intuitionistic uncertain linguistic environment was developed. Finally, an illustrative example is selected to verify the practicality and feasibility of the proposed procedure.

1.1.1 - Previous detail studies and Literatures:

Chen and Tan [1994] were presented a new method for handling multicriteria fuzzy decision-making problems, in which the characteristics of the alternatives are represented by interval-valued fuzzy sets, and some techniques were developed to calculate the degree of similarity between interval-valued fuzzy sets. The proposed method was more flexible than the one we presented earlier (Chen et al., 1989.) because it allows the criteria values of the alternatives to be represented by real intervals rather than crisp real values between zero and one.

Yager [1988] made on n-ordered weighted averaging aggregation operators in multicriteria decision making, and he is primarily concerned with the problem of aggregating multi-criteria to form an overall decision function. He introduced a type of operator for aggregation called an ordered weighted aggregation (OWA) operator and investigates the properties of this operator. The OWA's performance was found to be between those obtained using the AND operator, which requires all criteria to be satisfied, and the OR operator, which requires at least one criterion to be satisfied.

Xu and Yager [2006] investigated on few geometric aggregation operators based on intuitionistic fuzzy sets, and analyzed that the weighted geometric (WG) operator and the ordered weighted geometric (OWG) operator are two common aggregation operators in the field of information fusion. But these two aggregation operators are usually used in situations where the given arguments are expressed as crisp numbers or linguistic values. They developed some new geometric aggregation operators, such as the intuitionistic fuzzy weighted geometric (IFWG) operator, the intuitionistic fuzzy ordered weighted geometric (IFOWG) operator, and the intuitionistic fuzzy hybrid geometric (IFHG) operator, which extend the WG and OWG operators to accommodate the environment in which the given arguments are intuitionistic fuzzy sets which are characterized by a membership function and a non-membership function. Some numerical examples were given to illustrate the developed operators. Finally, we give an application of the IFHG operator to multiple attribute decision making based on intuitionistic fuzzy sets.

Xu and Chen [2007] discussed on an approach to group decision making based on interval-valued intuitionistic judgment matrices, and the ordered weighted aggregation operator and hybrid aggregation operator were developed for aggregating interval-valued intuitionistic preference information. Interval-valued intuitionistic judgment matrix and its score matrix and accuracy matrix are defined. Few of their desirable properties were investigated in detail. The relationships among interval-valued intuitionistic judgment matrix, intuitionistic judgment matrix, and complement judgment matrix, were discussed. On the basis of the arithmetic aggregation operator and hybrid aggregation operator, an approach to group decision making with interval-valued intuitionistic judgment matrices is given. Finally, a practical example is provided to verify the effectiveness of the developed approach.

Xu [2005] studied an overview of methods for determining OWA Weights, and the ordered weighted aggregation (OWA) operator has received more and more attention since its appearance. One key point in the OWA operator is to determine its associated weights. They first briefly reviewed existing main methods for determining the weights associated with the OWA operator, and then, motivated by the idea of normal distribution, they developed a novel practical method for obtaining the OWA weights, which is distinctly different from the existing ones. The method can relieve the influence of unfair arguments on the decision results by weighting these arguments with small values.

Robinson and Amirtharaj [2011] discussed a short primer on the Correlation coefficient of Vague sets, generalized intuitionistic fuzzy sets and vague sets as the concept of fuzzy sets. Various researchers have studied the vagueness of data through vague sets, and it was later demonstrated that vague sets are indeed intuitionistic fuzzy sets. Since its entry in the literature, vague set theory has received increased attention. Many real-life problems involve information in the form of vague values, due to the increasing complexity of the socio-economic environment and the vagueness of the inherent subjective nature of human thinking. Instead of using point-based membership as in fuzzy sets, interval-based membership is used in a vague set. They presented a detailed comparison between vague sets and intuitionistic fuzzy sets, from various perspectives of algebraic properties, graphical representations, and practical applications. Methods of calculating the correlation coefficient of intuitionistic fuzzy sets and interval-valued intuitionistic fuzzy sets were already found in the literature. They defined the correlation coefficient of vague sets through simple examples.

Park, Kwun, Park, and Park [2009] investigated that correlation coefficient of the interval-valued intuitionistic fuzzy sets and its application to multiple attribute group decision making problems, and various attempts have been made by researchers on the study of vagueness of data through intuitionistic fuzzy sets and vague sets, and also it was shown that vague sets are intuitionistic fuzzy sets. But there were algebraic and graphical differences between vague sets and intuitionistic fuzzy sets. An attempt was made to define the correlation coefficient of interval vague sets lying in the interval [0, 1], and a new method for computing the correlation coefficient of interval vague sets lying in the interval [-1, 1] using alpha - cuts over the vague degrees through statistical confidence intervals is presented by an example. The new method proposed in this paper produces a correlation coefficient in the form of an interval Vague Correlation Coefficient of Interval Vague Sets.

Aktas and Cagman [2007] studied on soft sets and soft groups, and Molodtsov introduced the concept of soft set theory, which can be used as a generic mathematical tool for dealing with uncertainty. In this paper they introduced the basic properties of soft sets and compare soft sets to the related concepts of fuzzy sets and rough sets. They give a definition of soft groups and derive their basic properties using Molodtsov's definition of the soft sets. Atanassov [1994] explained that different operators are defined over the interval valued intuitionistic fuzzy sets and their basic properties are studied. Aygunougluand Aygun[2009] introduced the fuzzy soft group and fuzzy soft uniform spaces as a view point of the encourage approach. They investigated the relationship among fuzzy soft uniformities, fuzzy soft topologies and fuzzy soft interior operators. They studied several fuzzy soft topologies induced by a fuzzy soft uniform space.

Bustince and Burillo [1996] analyzed that vague sets are intuitionistic fuzzy sets, and they recapitulated the definition given by Atanassov (1983) of intuitionistic fuzzy sets as well as the definition of vague sets given by Gau and Byehrer (1993) and see that both definitions coincide.Chen and Hsieh [1999] discussed graded mean integration representation of generalized fuzzy number, and they studied on fuzzy transportation problem for industries to reduce the transportation cost of a commodity from one source to another source. They put transportation cost, demand and supply all are in fuzzy trapezoidal number because the fuzzy number satisfy the condition of vagueness. Here they are using the proposed algorithm to obtain the fuzzy optimal solution of fuzzy transportation problem with membership function.

Chen and Tan [1994] handled a multi-criteria fuzzy decision-making problem based on vague sets, and Chen et. al., (Fuzzy Sets and Systems 67 (1994) (163-172)) present some techniques for handling multicriteria fuzzy decision-making problems based on vague set theory. They provide some functions to measure the degree of suitability of each alternative with respect to a set of criteria presented by vague values. However, in some cases, these functions do not give sufficient information about alternatives. They provided new functions to measure the degree of accuracy in the grades of membership of each alternative with respect to a set of criteria represented by vague values. The proposed functions gave additional information about alternatives. The techniques can provide more useful ways than those of Chen to efficiently help the decision-maker to make his decision.

Chiangand Lin [1999] studied on correlation of fuzzy sets, and correlation coefficient of random variables have wide applications in statistical analysis. Their work was extended the applications to the fuzzy environment, with a methodology for calculating the correlation coefficient of fuzzy numbers developed. Different from previous studies, the correlation coefficient calculated is a fuzzy number, rather than a crisp value. The idea is based on Zadeh's extension principle. A pair of nonlinear programs was formulated to find the alpha-cut of the fuzzy correlation coefficient. From different values of alpha, the membership function of the fuzzy correlation coefficient was constructed. To illustrate how to interpret the fuzzy correlation coefficient in real world applications, the correlation between the technology level and management achievement from a sample of 15 machinery firms in Taiwan was exemplified. All indications showed that the correlation between technology and management in Taiwan machinery firms is rather low.

Gau and Buehrer [1994] analyzed on vague sets, and they recapitulated the definition given by Atanassov (1983) of intuitionistic fuzzy sets as well as the definition of vague sets given by Gau and Byehrer (1993) and see that both definitions coincide. Junand Park [2008] made on applications of soft sets in ideal theory of BCK/ BCI-algebra and Molodtsov [D. Molodtsov, Soft set theory-First results, Comput. Math. Appl. 37 (1999) 19-31] introduced the concept of the soft set as a new mathematical tool for dealing with uncertainties that is free from the difficulties that have troubled the usual theoretical approaches. Jun [Y. B. Jun, Soft BCK/BCI-algebras, Comput. Math. Appl.56 (2008) 1408-1413] applied first the notion of soft sets by Molodtsov to the theory of BCK/BCI-algebras. They introduced the notion of soft p-ideals and p-idealistic soft BCI-algebras and then investigated their basic properties. Using soft sets, they gave characterizations of (fuzzy) p-ideals in BCI-algebras. They provided relations between fuzzy p-ideals and p-idealistic soft BCI-algebras.

Liu and Guan [2009] made an approach for multiple attribute decision-making based on vague sets, and solved multiple attribute group decision making MAGDM problems has become one of the most important researches in recent days. In situations where the information or the data is of the form of an Intuitionistic Triangular Fuzzy Number ITrFNor intuitionistic trapezoidal fuzzy number ITzFN, a new distance function is defined for ranking the alternatives in the decision making process. After processing the decision information through a sequence of arithmetic aggregation operators, namely, the intuitionistic triangular fuzzy weighted arithmetic averaging ITrFWAA, intuitionistic triangular fuzzy ordered weighted averaging ITrFOWA operator and the intuitionistic triangular fuzzy hybrid aggregation ITrFHA operator, the proposed distance function is utilized to rank the best alternative. A model is proposed to solve MAGDM problems using the developed distance formula defined for ITrFNs. Numerical illustration is provided, and comparisons are made with some of the existing MAGDM models and ranking procedures.

Lu and Ng [2009] maintained consistency of vague databases using data dependencies, and the works deal with the application of fuzzy logic in a relational database environment with the objective of capturing more meaning of the data. It is shown that with suitable interpretations for the fuzzy membership functions, a fuzzy relational data model can be used to represent ambiguities in data values as well as impreciseness in the association among them. Relational operators for fuzzy relations have been studied, and applicability of fuzzy logic in capturing integrity constraints has been investigated. By introducing a fuzzy resemblance measure equal for comparing domain values, the definition of classical functional dependency has been generalized to fuzzy functional dependency (ffd). The implication problem of ffds has been examined and a set of sound and complete inference axioms has been proposed. Next, the problem of lossless join decomposition of fuzzy relations for a given set of fuzzy functional dependencies is investigated. It is proved that with a suitable restriction on equal, the design theory of a classical relational database with functional dependencies can be extended to fuzzy relations satisfying fuzzy functional dependencies.

Maji, Roy, Biawas [2001] discussed on fuzzy soft sets, and they further contributed to the properties of fuzzy soft sets as defined and studied in the work of Maji et.al.,(2001), Roy and Maji (2007), and Yang et. al., (2007) and supported them with examples and counterexamples. They improved result by Maji et.al., (2001). Finally, they defined arbitrary fuzzy soft union and fuzzy soft intersection and proved De-Morgan inclusions and De-Morgan laws in fuzzy soft set theory.

Maji, Roy, and Biswas [2002] initiated an application of soft sets in a decision making problem, and they focused our discussion on the parameterization reduction of soft sets and its applications. First they pointed out that the results of soft set reductions are incorrect. They also observed that the algorithms used to first compute the reduct-soft-set and then to compute the choice value to select the optimal objects for a decision problem are not reasonable and they illustrated this with an example. Finally, they proposed a reasonable definition of parameterization reduction of soft sets and compare it with the concept of attributes reduction in rough set's theory. By using this new definition of parameterization reduction, they improved the application of a soft set in a decision making problem.

Wei, and Wang [2007] got few geometric aggregation operators interval-valued intuitionistic fuzzy sets and their application to group decision making and the intuitionistic fuzzy set (IFS) characterized by a membership function and a non-membership function, was introduced by Atanassov [K. Atanassov, "Intuitionistic fuzzy sets", Fuzzy Sets and Systems 20 (1986) 87-96] as a generalization of Zadeh' fuzzy set [L. A. Zadeh, "Fuzzy Sets", Information and Control 8 (1965) 338-353] to deal with fuzziness and uncertainty. They investigated the multiple attribute decision making (MADM) problems, in which the information about attribute weights is incomplete, and the attribute values are expressed in intuitionistic fuzzy numbers (IFNs). We first define the concept of intuitionistic fuzzy ideal solution (IFIS), and then, based on the IFIS and the distance measure, they established some optimization models to derive the attribute weights. Furthermore, based on the developed models, they developed some procedures for the rankings of alternatives under different situations, and extended the developed models and procedures to handle the MADM problems with interval-valued intuitionistic fuzzy information. Finally, they gave some illustrative examples to verify the effectiveness and practicability of the developed models and procedures.

Xu [2007] studied methods for aggregating interval-valued intuitionistic fuzzy information and their application to decision making, and the work was presented an interval-valued intuitionistic fuzzy cross-entropy measure based on the weighted reduction intuitionistic fuzzy sets of interval-valued intuitionistic fuzzy sets with adjustable weight vectors as an extension of existing fuzzy cross-entropy measures. Then a decision-making method was developed based on the proposed cross-entropy measure with the optimal weight vectors. In decision making, they established an optimal model based on the maximum standard deviation of the measure values of the alternatives to search for the optimal weight vectors in the adjustable weight vectors. According to the optimal weight vectors, they can obtain the interval-valued intuitionistic fuzzy cross entropy between the ideal alternative and an alternative to rank the alternatives and to determine the best one. Finally, two illustrative examples were employed to show the feasibility of the proposed method in practical applications, and then the comparison of the proposed method.

Xu and Yager [2006] did some geometric aggregation operators based on intuitionistic fuzzy sets and the weighted geometric (WG) operator and the ordered weighted geometric (OWG) operator are two common aggregation operators in the field of information fusion. But these two aggregation operators are usually used in situations where the given arguments are expressed as crisp numbers or linguistic values. They developed some new geometric aggregation operators, such as the intuitionistic fuzzy weighted geometric (IFWG) operator, the intuitionistic fuzzy ordered weighted geometric (IFOWG) operator, and the intuitionistic fuzzy hybrid geometric (IFHG) operator, which extend the WG and OWG operators to accommodate the environment in which the given arguments are intuitionistic fuzzy sets which are characterized by a membership function and a non-membership function. Some numerical examples were given to illustrate the developed operators. Finally, they gave an application of the IFHG operator to multiple attribute decision making based on intuitionistic fuzzy sets. Yager [1988] initiated an ordered weighted averaging aggregation operators in multi-criteria decision making, and incorporating further information into the ordered weighted averaging (OWA) operator weights is investigated. They proved that for a constant orness the minimax disparity model has unique optimal solution while the modified minimax disparity model has alternative optimal OWA weights. Multiple optimal solutions in modified minimax disparity model provide us opportunity to define a parametric aggregation OWA which gives flexibility to decision makers in the process of aggregation and selecting the best alternative. Finally, the usefulness of the proposed parametric aggregation method was illustrated with an application in metasearch engine.

1.1.2 Definition of the problem:

In Multiple Attribute Group Decision Making (MAGDM) models the problem is to:

- Determine the relevant attribute and alternatives.
- Determine the weights of the attributes (when unknown).
- Attach numerical measures to the relative importance of the attribute and to the impacts of the alternatives on these attributes.
- Process the numerical values to determine a ranking of each alternative.

Attach numerical measures to the attributes involved in the problem needs a careful study of the problem. There are various techniques available in the literature for attaching the numerical measures, namely, the Weighted Averaging (WA), Ordered Weighted Averaging (OWA), Induced-OWA, Geometric Aggregation, etc., out of which a suitable one should be chosen. In order to determine the weights for each attributes in MAGDM problems, different weight determining methods are proposed and utilized for decision making problems under interval- valued intuitionistic fuzzy sets.

1.1.3 Aims and objectives:

The overall aim of the proposed research work is to propose new algorithms for MAGDM problems using correlation measures to rank the alternatives, and also propose different weight determining methods especially when the attribute weights are completely unknown.

The overall objectives of the research work are listed below:

1. To study the different classes of Aggregation Operators and their properties.
2. To use the correlation coefficient for fuzzy soft sets and neutrosophic fuzzy sets in ranking the alternatives.
3. To propose weight determining methods when the attribute weights are completely known/unknown in MAGDM problems.
4. To compare all the proposed models for effectiveness.

1.1.4 Scope of the research work:

In this research work the correlation coefficient of fuzzy soft sets and neutrosophic fuzzy sets is used to rank the alternatives in MAGDM problems. The different types of weight determining methods are used in decision making models dealing with varieties of aggregation operators. The weight determining methods defined in this research work can also be used in Reniy's, Daroczy's and R-norm. Different classes of aggregation operators namely Hybrid OWA operators are utilized and any other operator already defined in the literature will also be comfortable for the process. The scope of the proposed research work is to provide decision makers with better tools for decision making, especially in uncertain situations of determining weights for the attributes or fuzzy environment. The proposed weight determining methods play an important role with decision makers to aggregate the decision information of the alternatives and the ideal solution in the decision process. Ultimately, the end result of the proposed research work will enhance the decision making process with new tools based on different weight determining methods for MAGDM problems under IVIFS environment.

1.1.5 Methodology:

Correlation coefficients of fuzzy soft sets and neutrosophic fuzzy sets are used as a tool to rank the alternatives in all the decision making (MAGDM) models presented in this work. Most of the aggregation operators used are similar to those of the operators of Wei, (2010a; 2010b; 2011.) when dealing with Intuitionistic Fuzzy sets (IFSs) and Interval-Valued Intuitionistic Fuzzy Sets (IVIFSs), Ordered Weighted Averaging (OWA) operators are used for aggregating the fuzzy information given in the form of decision matrices. Different methods of ranking the alternatives with the bottle neck problems of determining the weights of the attributes of the alternatives are compared for IVIFSs. The matrix method of determining weights, Maximal entropy OWA weights method for determining weights, Reniy's, Daroczy's and R-norm entropy weights method, Normal Distribution based method for weights are proposed and used for given MAGDM problems.

1.1.6 MAGDM with soft and neutrosophic theories:

Multi Attribute Group Decision Making (MAGDM) problems are wide spread in real life situations. A MAGDM problem is to find a desirable solution from a finite number of feasible alternatives assessed on multiple attributes, both quantitative and qualitative. To choose a desirable solution, the decision maker often provides his/her preferred information in the form of numerical values, such as exact values, interval number values and fuzzy numbers.

However, under many conditions, numerical values are inadequate or insufficient to model real-life decision problems. Indeed, human judgments including preference information may be stated in intuitionistic fuzzy information. Hence, MAGDM problems under the intuitionistic fuzzy environment are an interesting area of study for researchers recently.

Processing of MAGDM problems with intuitionistic fuzzy information or vague fuzzy information, sometimes, leads to attribute values taking the form of intuitionistic or vague fuzzy number, respectively. The information about attribute weights may sometimes be known, partially known or be completely unknown. MAGDM problems are assumed to have a predetermined, limited number of decision alternatives.

Solving an MAGDM problem involves sorting and ranking, and can be viewed as an alternative method for combining information in a problem's decision matrix together with additional information from the decision maker to determine a final ranking or selection from the alternatives. Besides the information contained in the decision matrix, all but the simplest MAGDM techniques require additional information from the decision matrix to arrive at a final ranking/selection.

Szmidt and Kacprzyk [2003] proposed some solution concepts like the intuitionistic fuzzy core and consensus winner in group decision making with intuitionistic fuzzy preference relations. They also developed an approach to aggregate the individual intuitionistic fuzzy preference relations into a social fuzzy preference relation based on fuzzy majority equated with a fuzzy linguistic quantifier.

Szmidt and Kacprzyk [2002] introduced several distance functions and similarity measures for IFSs which were later used in various MAGDM problems. They investigated MADM with intuitionistic fuzzy information and constructed several linear programming models to generate optimal weights for attribute. They also presented a new method for handling multiple attribute fuzzy decision making problems, where the characteristics of the alternatives are represented by intuitionistic fuzzy sets.

Herrera et. al., [1999] developed an aggregation process for combining numerical, interval- valued and linguistic information, and then proposed different extensions of this process to deal with contexts where the information can appear as IFSs or multi-granular linguistic information.

Xu and Chen [2006] developed some geometric aggregation operators for MADM problems. They developed an evaluation function for the decision making problem to measure the degrees to which alternatives satisfy/do not satisfy the decision maker's requirement.

Chen and Tan [1994] presented new techniques for handling multiple attribute fuzzy decision making problems based on vague set theory. Also Hong and Choi [2000] provided some new techniques for handling multiple attribute fuzzy decision making problems based on vague set theory.

1.1.7 Organization of the thesis:

The thesis is divided into Seven chapters:

Chapter I - Overall contributions and Preliminaries.

Chapter II - Vague fuzzy hybrid weighting operators in multiple group decision making problems.

Chapter III - Attributes weight determination for fuzzy soft MAGDM problems.

Chapter IV - Correlation and ranking analysis using Neutrosophic fuzzy sets in Multi-Criteria single-valued decision making problems.

Chapter V - Neutrosophic fuzzy models with ranking technique using distance of MAGDM.

Chapter VI - Quantifier guided aggregation under neutrosophic fuzzy techniques.
Chapter VII - A comparative study on five models.

1.1.8 Original contributions and thesis Structures:

In the chapter I, concepts and terms which are relevant to the work are presented. Review of literature related to the present study is also given in this chapter. The research works carried out by the author is presented in chapters II to VI.

1.2 - Vague fuzzy hybrid weighting operators in multiple group decision making problems:

Using Algorithm I for a developed model of MAGDM, the following are finalized.

In chapter II, the weighted averaging operator from Renyi's, Daroczy's and R-norm entropies, vague fuzzy weighted averaging operator and vague fuzzy hybrid weighted averaging operator for vague sets are proposed. Also a general model for decision making utilising these operators is proposed for vague sets together with a new distance function defined based on the distance functions from the literature.

1.3 - Attributes weight determination for fuzzy soft MAGDM problems:

This chapter discusses different classes of aggregation operators and their properties with an attempt being made to present decision making models with correlation coefficient for IVIFSs. Correlation coefficient of IFSs proposed by Zeng & Li [2007] and correlation coefficient for IVIFSs proposed by Park et. al., [2009] are reviewed and utilized to rank alternatives in the MAGDM models. Ordered Weighted Geometric and Induced Ordered Weighted Geometric operators are used for the MAGDM model proposed for IVIFSs. Numerical illustration is provided for MAGDM model of IVIFSs. Park et. al., [2009] defined the correlation of A, B IVIFS(X) including the hesitation degree as follows:

Using Algorithm II for the proposed model in the fuzzy soft MAGDM problem, the Multiple Attribute Group Decision Making(MAGDM) problems are investigated in which all the information provided by the decision makers is presented as fuzzy soft sets and fuzzy soft decision matrices, and the information about attribute weight is partially known. The model is based on the attribute weights calculated from partially known information using the score function of Xu (2007) or it is based on the Gaussian distribution function for calculating the completely unknown attribute weights. The fuzzy soft ordered weighted averaging (FSOWA) operator was utilized to aggregate all individual fuzzy soft decision matrices provided by the decision makers into the collective fuzzy soft decision matrix, and then we use the obtained attribute weights and the fuzzy soft information in the collective fuzzy soft decision matrix are used to get the overall fuzzy soft values of alternatives. The fuzzy soft matrices are converted into a single fuzzy decision matrix using average, and then the alternatives are ranked according to the ranks between the fuzzy soft data (FSDs) using distance, through the techniques like as average, and score function in terms of weights. Then the most desirable one(s) selected. Finally, numerical examples are used to illustrate the effectiveness of the proposed approaches.

1.4 - Correlation and ranking analysis using neutrosophic fuzzy sets in multi-criteria single-valued decision making problems:

In this chapter, we investigate the group decision making problems in which all the information provided by the decision makers is presented as interval-valued intuitionistic fuzzy decision matrices where each of the elements is characterized by interval-valued intuitionistic fuzzy number (IVIFN), and the information about attribute weights is partially known.

We use the interval-valued intuitionistic fuzzy hybrid geometric (IIFHG) operator and interval-valued intuitionistic fuzzy ordered weighted geometric (IIFOWG) operator to aggregate all individual interval-valued intuitionistic fuzzy decision matrices provided by the decision makers into the collective interval-valued intuitionistic fuzzy decision matrix, and then we use the score function to calculate the score of each attribute value and construct the score matrix of the collective interval-valued intuitionistic fuzzy decision matrix. From the score matrix and the given attribute weight information, we establish an optimization model.

Using Algorithm III for the developed model, we obtained the following:

As a generalization of intuitionistic fuzzy sets, neutrosophic sets (NSs) can be better handle the incomplete, indeterminate and inconsistent information, which have attracted the widespread concerns for researchers. In this chapter some new correlation coefficient and ranking method are introduced using neutrosophic fuzzy operators and fuzzy average operator in a single-valued neutrosophic environment. Firstly, the definition and operational laws of single-valued neutrosophic numbers (SVNNs) are introduced. Then, the single-valued neutrosophic average operator and the single-valued ranking techniques in neutrosophic are developed, and few properties of these operators are also analyzed. Furthermore, a method for solving multi-criteria decision-making (MCDM) problems is explored based on the correlation coefficient and raking technique. Finally, an illustrative example is shown to verify the effectiveness and practicality of the proposed method.

1.5 - Neutrosophic fuzzy models with ranking technique using distance of MAGDM

The following are investigated using Algorithm IV of the developed model.

Having to use crisp values is one of the problematic points in the crisp evaluation process. As some attributes are difficult to measure by crisp values, they are usually neglected during the evaluation. Another reason is about mathematical models that are based on crisp values. These methods cannot help decision makers ambiguities, uncertainties and vagueness that cannot be handled by crisp values. The use of fuzzy set theory, especially vague set theory allows us to incorporate unquantifiable information, incomplete information, non-obtainable information and partially ignorant facts into the decision model. Decisions have to be made in complex contexts, characterized by the presence of multiple evaluation aspects, are normally affected by uncertainty, which is essentially from the insufficient or imprecise nature of input data as well as the subjective and evaluative preferences of the decision maker.In an age of extensive competition among organizations, managers search for efficiency and excellence in solving decision problems. An effective group decision mechanism would enhance the quality of the group decision making process, and thus improve the performance of the organization. This model proposes a group decision model which differs from the traditional ones and considers different aspects of attribute weights, alternative priorities and group ideal solutions to be taken into the construction. Therefore, the proposed model would result in a decision which is more realistic and acceptable for decision makers, because it includes the vague entries for the correlation coefficient which is used for ranking the preferences.

Due to the development of e-democracy and information technology, decision makers are now able to conclude a group decision without a face-to- face meeting. In such cases, decision makers only need to rank alternatives using any multiple attribute decision making technique by the aggregation of their preferences, which could be attained by the proposed model. As a result, and without much time consumption, the problems of aggregation of preferences can be solved and the managerial operations of the organization can be enhanced. The proposed model is based on the assumption that the decision makers will always honestly report their preferences. Even if they do not, the method of generating weights when the expert weights are not given explicitly can be utilized. Moreover, varieties of methods on MAGDM have been proposed in recent years, such as problems in linguistic variables, weight elicitation and distance measurement. Further study may thus utilize some existing revised MAGDM approaches to extend the proposed model. In the proposed method, the correlation coefficient of vague sets is used as a tool for ranking the alternatives. Three different methods were proposed for the same decision making situation dealing with known weights and unknown weights of the experts and a comparison is made between the proposed models and the existing models in the literature.

1.6 - Quantifier guided aggregation under neutrosophic fuzzy techniques

Using Algorithm V the followings are found:

Neutrosophic fuzzy decision matrices are taken for m number of alternatives and n number of decision makers. Here k numbers of such decision matrices are assumed. We select a new neutrosophic fuzzy decision matrix using maximum in truth membership, and minimum in indeterministic membership and false membership.Weights are generated by using quantifier guided entropy method. Then the reduced matrix is obtained using given decision matrices and max-mini matrix, distance is calculated through the standard observations and selects the best alternative.

1.7 - A comparative study on five models

A detailed discussion among all five models in the chapters II to VI are analysed, and a better model is chosen among the given models.

CONCLUSION

A new approach for multiple attribute group decision making (MAGDM) problems where the attribute weights and the expert weights are real numbers and the attribute values take the form of vague values, is presented in this chapter. Since families of ordered weighted averaging (OWA) operators are available in the literature, and only a few are available for vague sets, the vague ordered weighted averaging (VOWA) operator and the induced vague ordered weighted averaging (IVOWA) operator are introduced in this chapter and utilized for aggregating the vague information. The correlation coefficient for vague sets is used for ranking the alternatives and a new

MAGDM model is developed based on the IVOWA operator and the vague weighted averaging (VWA) operator. In addition to the proposed model, two different models are proposed based on Linguistic Quantifiers for the situation when the expert weights are completely unknown. An illustrative example is given, and a comparison is made between the models to demonstrate the applicability of the proposed approach of MAGDM.