Preface

In most real situations, such as economic management and engineering management, fuzziness (or vagueness uncertainty) is inherited in decision making problems and decision process. Fuzziness seems to be suitably dealt with the fuzzy set introduced by L.A. Zadeh and the intuitionistic fuzzy set (IFS) introduced by K.T. Atanassov. The latter is an important and a successful extension of the former through adding a non-membership degree (or function). Researchers and practitioners in disciplines and fields have acknowledged the significance of the fuzzy set and the IFS. Therefore, it is very important to express and measure fuzziness in real decision making problems and hereby develop effective and practical models and methods. In fact, in recent years, the fuzzy set and the IFS have been extensively explored and achieved a great success in many fields such as business, management, economics, energy and natural resource, medical treatment, environment, safety, and transportation. In order to comprehensively reflect the advance in the fuzzy set and the IFS, the book titled "Theoretical and Practical Advancements for Fuzzy System Integration" has been edited to collect the original research in this area.

Sixteen proposals for chapters for the book titled "Theoretical and Practical Advancements for Fuzzy System Integration" have been received and carefully reviewed. Thirteen chapter submissions are finally accepted to publish in the aforementioned book. In other words, this edited book has 13 chapters.

Chapter 1 titled "Fuzziness: A Mathematical Tool" is written by A. K. Sahu, N. K. Sahu, and A. K. Sahu. They pointed out decision information usually is uncertain, vague, and inconsistent. In this case, the decision information seems to be easily collected in terms of the fuzzy set, which is observed as an important and a powerful tool that aids numerous researchers and learners in a variety of ways and in countless disciplines by transforming oral information into mathematical data. The majority of the conventional tools for computing, analysis, and modeling only deal with the defined, deterministic, certain, and precise information. Chapter 1 gave an idea to the learners and researcher about the basic concepts of the fuzzy sets and fuzzy numbers and their applications. The main purpose of Chapter 1 is to impart fuzzy knowledge to the readers and new learners so that they augment and disseminate the fuzzy set theory into new application fields to benefit the society and mankind.

Chapter 2 titled "Some Recent Defuzzification Methods" is written by H. Kumar. Defuzzification is a process that transforms a fuzzy number into a crisp value (i.e., real number). In fuzzy modeling, fuzzy optimization, and fuzzy control, defuzzification is employed to transform the fuzzy outputs from the systems into crisp values due to the fact that all fuzzy sets inferred by fuzzy inference in the fuzzy rules have to be aggregated into one single number as the output of the fuzzy model. Currently, there are numerous defuzzification methods. Chapter 2 discussed some recent defuzzification techniques such as the sums' center method, the height method, the magnitude method, the middle point method, and the Robust's ranking method as well as their applications.

Chapter 3 titled "Interval-Valued Intuitionistic Fuzzy Multi-Attribute Decision Making Based on Satisfactory Degree" is written by G. F. Yu, D.-F. Li, and J. M. Qiu. They focused on how to solve multi-attribute decision making problems in which ratings of alternatives on attributes are expressed with interval-valued IFSs and preference information on attributes is incomplete. Chapter 3 constructed a nonlinear programming model based on the idea of the determined intuitionistic fuzzy satisfactory degree which is the ratio of the square of the weighted Euclidean distance between an alternative and an interval-valued intuitionistic fuzzy negative ideal solution to the sum of the square of the weighted Euclidean distance between the interval-valued intuitionistic fuzzy negative ideal solution and the interval-valued intuitionistic fuzzy positive ideal solution. The general satisfactory degrees of alternatives are obtained. A new ranking method is developed to generate the order of the alternatives. The proposed model and method are illustrated with a real example.

Chapter 4 titled "Intuitionistic Fuzzy Distance-Based Intuitionistic Fuzzy TOPSIS Method and Application to MADM" is written by J. X. Nan, T. Wang, and J. J. An. In Chapter 4, the intuitionistic fuzzy distance is defined to measure difference between two triangular intuitionistic fuzzy numbers (TIFNs) and some important and useful metric properties are also discussed. Based on the concepts of the defined intuitionistic fuzzy distance and the Technique for order Preference by Similarity to Ideal Solution (TOPSIS), a new extended TOPSIS is developed to solve multi-attribute decision making (MADM) problems in which the ratings of alternatives on attributes are expressed with TIFNs. In this method, the intuitionistic fuzzy distances between alternatives and the TIFN positive ideal-solution as well as the TIFN negative ideal-solution are calculated. Then, the relative closeness degrees of alternatives to the TIFN positive ideal solution can be obtained. The relative closeness degrees are also TIFNs, which are used to generate the ranking order of alternatives according some ranking method of TIFNs. The proposed intuitionistic fuzzy distance and extended TOPSIS can be applicable to MADM problems in which the ratings of alternatives on attributes are expressed with intuitionistic fuzzy numbers, particularly trapezoidal intuitionistic fuzzy numbers.

Chapter 5 titled "Fuzzy-AHP: A Boon in 3PL Decision Making Process" is written by N. K. Sahu, A. K. Sahu, and A. K. Sahu, who discussed a kind of selection problems of the third party logistics for organizations (or firms). The third party logistics' selection which involves various factors and attributes is a challenging problem. Chapter 5 explored the fuzzy set theory and presented a fuzzy Analytical Hierarchy Process (AHP) model to facilitate the managers of organizations to deal with the third party logistics' decision making problems. The overall performances of the third party logistics' service providers are greatly influenced by many significant factors/attributes such as quality, reliability, service assurance, shipment cost, and customer relationship. In the constructed fuzzy AHP model, service level, financial security capabilities, location, global presence, relationship management, and client fulfillment are chosen to represent the first level's indices. The aforementioned factors have various sub-factors/attributes which are chosen to represent the second level's indices. Various researchers have constrained their works to the first level indices and have not considered the second level indices, which is a crucial part of today's practical decision making process for the third party logistics' selection. Hereby the AHP accompanied with the fuzzy set theory is used to solve industrial Logistics problems. The purpose of Chapter 5 is to develop a fuzzy based AHP method for solving benchmarking (preference ranking orders of alternatives under criteria) problems. The proposed method facilitates the managers of firms to make the verdict towards choosing the best third party logistics' service provider(s).

Chapter 6 titled "Intuitionistic Fuzzy Set Theory with Fair Share CPU Scheduler: A Dynamic Approach" is written by S. Raheja, who mainly discussed fair share CPU scheduler, which equally/statically

distributes the processor time between groups, users and tasks, as opposed to the fixed distribution among tasks (round Robin schedulers). Fairness should be the major consideration for any scheduler. Traditional schedulers considered that every task belongs to a different user. Therefore, schedulers like round Robin logically distribute equal CPU services/processor time to all tasks. When several tasks need a processor, operating system often allots processor time slices on a round Robin fashion, i.e., scheduler distributes equal time to all tasks having same priority. However, the static approach may result in the distribution of small processor time to a busy group slows down the performance of a system. The main objective of Chapter 6 is to propose a dynamic approach to distributing the processor time of fair share schedulers based on the IFS theory. The fair share scheduler contains three modules. The first module is the intuitionistic fuzzy inference system IFIS-DCS, the second module is the intuitionistic fuzzy inference system IFIS-DP, and the third module is the scheduling algorithm. The proposed method can deal with the impreciseness and inexactness of tasks, dynamically shares processor time among groups, users as well as tasks, and provides dynamic priority to each task of active users. Moreover, the proposed method also improves the performance of system over the fair share scheduler in terms of average response time, average normalized turnaround time, and number of context switches.

Chapter 7 titled "MAGDM Problems with Correlation Coefficient of Triangular Fuzzy IFS" is written by J. P. Robinson and E. C. Henry Amirtharaj. The concepts of correlation coefficients of IFSs, interval-valued IFSs, triangular IFSs, and trapezoidal IFSs are very important and have been presented in many fields. Chapter 7 proposed the correlation coefficient of triangular fuzzy IFSs (TFIFSs) and developed a new method for solving uncertain multiple attribute group decision making (MAGDM) problems with TFIFSs. In this method, the triangular fuzzy intuitionistic fuzzy ordered weighted averaging (TFIFOWA) operator and the triangular fuzzy intuitionistic fuzzy ordered weighted geometric (TFIFOWG) operator are proposed. Hereby the new decision making models are constructed to deal with the decision situations where expert weights are completely unknown. Also some comparisons are made with existing ranking methods.

Chapter 8 titled "Credibility Hypothesis Testing of Variance of Fuzzy Normal Distribution" is written by S. Sampath and B. Ramya, who considered the problem of test procedures for testing credibility hypotheses about the variance of fuzzy normal distribution assuming that the expected values of the distributions mentioned under null and alternative credibility hypotheses are known and equal *a priori*. Chapter 8 discussed some cases where the underlying hypothesis is simple and composite (one sided). The tests have been derived with the help of the membership ratio criterion. Some important and useful properties possessed by the developed tests such as the best credibility rejection region and uniformly best rejection region have been studied. The validity and feasibility of the derived tests are illustrated with several examples.

Chapter 9 titled "Application of Fuzzy Soft Set in Patients' Prioritization" is written by S. A. Rahimi, who is concerned access to healthcare services and long waiting time which is one of the main issues in OECD countries including Canada and United States. Healthcare organizations (or hospitals) cannot increase their limited resources nor treat all patients simultaneously. As a result, patients' access to these services should be prioritized so that the scarce (or limited) resources are used in the best way. Hereby in patients' prioritization problems there appear some challenging aspects such as multiple conflicting criteria, incomplete and imprecise data, associated risks that threaten patients on waiting lists, uncertainties in clinicians' decisions, decision maker group's opinions, and system's dynamic behavior. Inappropriate prioritization of patient waiting for treatment may directly affect on inefficiencies in healthcare delivery, quality of care, and most importantly on patients' safety and their satisfaction. Inspired by these facts,

Chapter 9 discussed the importance of using fuzzy logic in medical area and proposed a novel hybrid framework to prioritize patients based on the fuzzy soft set.

Chapter 10 titled "Performance Estimation of Firms by G-L-A Supply Chain under Imperfect Data" is written by A. K. Sahu, N. K. Sahu, and A. K. Sahu. In recent decade, for supply chain management, many methods were proposed to solve various problems of industrial sectors, such as assessment of resiliency of supplier against disasters, waste management equipments availability in manufacturing firms, green performance, and responses of firms towards their clients. Performance measurement is utilized as a tool to quantify overall efficiency via the green, lean, and agile (G-L-A) supply chain activities of firms, where the green supply chain agenda is to control and diminish pollution and the lean supply chain helps to reduce the waste of firms, while the agile supply chain manages to respond to clients as quick as possible. Chapter 10 proposed a multi-criterion decision making performance appraisement module (constituted by mixing the segregated green, lean and agile supply chain measures and their corresponding interrelated metrics) conjunctive with fuzzy performance index model, which is used to evaluate the overall performance of firms. In addition, an incentre of the centroid method is proposed to classify ill and strong G-L-A metrics of firms so that managers could raise their firms' performance to standard levels.

Chapter 11 titled "Appraise the Economic Values of Logistic Handling System under Mixed Information" is written by A. K. Sahu, N. K. Sahu, and A. K. Sahu, who considered the problems of quantifying the economic values of material handling systems. In recent years, assessments of firm (or corporation) logistic activities are found as a historic topic in real industrial management. Each parameter (or factor, attribute) leads the trait role in relation to materialize the economic values of material handling systems, which may result in the so-called a kind of multi-criteria decision making problems with observed data rather than verbal data. Thus, it is observed that these problems are resolved with less computation task by exploration of new effective algorithmic techniques. Chapter 11 proposed a new multi-level multi-criterion decision making algorithmic technique for appraising the economic values of material handling systems (i.e., candidates or alternatives) under subjective (linguistic information provided by personnel) or objective or subjective cum objective information. The proposed technique can be implemented to resolve miscellaneous quandaries of industries, such as performance measurement of supply chain management, benchmarking of advanced manufacturing technologies, port selection, shipping logistic route evaluation, layout evaluation, and banking sector evaluation. Chapter 11 displayed a flexible decision support system for quantifying the economic values of material handling system alternatives.

Chapter 12 titled "Benchmarking of Advanced Manufacturing Machines Based on Fuzzy-TOPSIS Method" is written by A. K. Sahu, A. K. Sahu, and N. K. Sahu, who studied the evaluation and management of advanced manufacturing machines. It is observed that the evaluation of the most appropriate computer numerical control (CNC) machine tool is the foremost issue for sustaining the advanced manufacturing production units at the competitive global market place. In last years, many evaluation parameter/criteria/attribute such as the cost, tool length, tool diameter, metal removal rate, and X-Y-Z-axis movement of tool are taken into account except the productivity, precision, accuracy, and reliability prior to purchasing/electing CNC machine tools among the preferred alternatives. Chapter 12 developed a new extended TOPSIS algorithmic technique with trapezoidal fuzzy numbers for appraising and benchmarking the preferable CNC machine tools (i.e., options or alternatives). In this method, the qualitative and quantitative parameter/criteria/attributes are considered, where subjective assessments of experts' panel (the decision making group) on qualitative criteria are integrated into electing the best CNC machine tool. The proposed method in Chapter 12 may solve some real life decision making problems such as

appraisement, evaluation, and benchmarking of cars, buses, trucks, plant layouts, aero planes, material handling equipments, and robots.

Chapter 13 titled "Prediction of Solar and Wind Energies by Fuzzy Logic Control" is written by S. Faquir, A. Yahyaouy, H. Tairi, and J. Sabor, who presented a study of photovoltaic panels and wind turbines and proposed a simulator based on fuzzy logic control (FLC) to estimate the wind and solar powers under any weather conditions. These two energy sources are very useful renewable energies that can be combined together in one hybrid system to increase system's efficiency. The choice of a mathematical model to determine the output power of each source depends on different parameters. Considering lots of parameters and different weather conditions makes the mathematical modeling too complex to be implemented. Chapter 13 proposed the fuzzy modeling to predict the photovoltaic and wind turbine powers from natural factors, temperature, lighting, and wind speed and considering any weather conditions. Results obtained from previous work were compiled and used to determine the values of the fuzzy variables' intervals. The photovoltaic and wind turbine power values predicted from the fuzzy modeling were compared to the data obtained from the simulation and the difference error was very small. The obtained fuzzy modeling values can be used as input values for a hybrid renewable system composed of photovoltaic panels, a wind turbine, and storage units such as batteries that can be implemented to supply a load demand for a site.

This edited book aims to provide relevant theoretical frameworks and the latest empirical research findings in the area of fuzzy sets, IFSs, and fuzzy systems. It is written for professionals who want to improve their understanding of fuzzy sets and IFSs which are applied to different fields under the background of the global economy and networks economy. Also this edited book aims to develop new theory and methods of fuzzy sets, IFSs, and their systems and extend the application ranges or fields.

It is addressed to people in theoretical researches and practical applications from different fields and disciplines such as:

- Decision science,
- Game theory,
- Management science,
- Operational research,
- Fuzzy sets or fuzzy mathematics,
- Applied mathematics,
- Industrial engineering,
- Finance,
- Applied economics,
- Expert system, and
- Social economy as well as artificial intelligence.

Moreover, it is also addressed to teachers, postgraduates, and doctors in colleges and universities in different disciplines or majors:

- Decision analysis,
- Management,
- Operation research,
- Fuzzy mathematics,

- Fuzzy system analysis,
- Applied mathematics,
- Systems engineering,
- Project management,
- Supply chain management,
- Industrial engineering,
- Applied economics, and
- Hydrology and water resources.

Finally, the editor would like to thank all the authors (contributors) of this edited book and all the reviewers who cost their valued times and energies to review this edited book and give excellent comments and constructive suggestions.

Deng-Feng Li
Fuzhou University, China
September 20, 2016