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Hesitant Fuzzy Sets Theory

Springer

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Preface

When people make a decision, they are usually hesitant and irresolute for one thing or another which makes it difficult to reach a final agreement. For example, two decision makers discuss the membership degree of an element to a set, and one wants to assign 0.6 but the other 0.8. Accordingly, the difficulty of establishing a common membership degree is not because we have a margin of error, or some possibility distribution values, but because we have a set of possible values. To deal with such cases, Torra and Narukawa (2009) introduced the concept of hesitant fuzzy set (HFS). The HFS, as one of the extensions of Zadeh (1965)'s fuzzy set, allows the membership degree that an element to a set presented by several possible values, and can express the hesitant information more comprehensively than other extensions of fuzzy set. In 2011, Xu and Xia defined the concept of hesitant fuzzy element (HFE), which can be considered as the basic unit of a HFS, and is also a simple and effective tool used to express the decision makers' hesitant preferences in the process of decision making. Since then, our research group has done lots of research work on aggregation, distance, similarity and correlation measures, clustering analysis, and decision making with hesitant fuzzy information.

In this book, we give a thorough and systematic introduction to the main research results in hesitant fuzzy theory, which include the hesitant fuzzy aggregation techniques, the hesitant fuzzy preference relations, the hesitant fuzzy measures, the hesitant fuzzy clustering algorithms, and the hesitant fuzzy multi-attribute decision making methods, etc. We organize this book into four chapters that deal with four different but related issues, which are listed below:

Chapter 1 introduces a series of hesitant fuzzy aggregation operators. We first introduce the hesitant fuzzy elements (HFEs), give their comparison methods, basic operational laws, and their desirable properties. Based on these operations, we develop lots of operators for aggregating HFEs, such as the hesitant fuzzy weighted aggregation operators, the generalized hesitant fuzzy weighted aggregation operators, the hesitant fuzzy ordered weighted aggregation operators, the generalized hesitant fuzzy ordered weighted aggregation operators, the hesitant fuzzy hybrid aggregation operators, the generalized hesitant fuzzy hybrid aggregation operators, the hesitant fuzzy Bonferroni means, the hesitant fuzzy aggregation operators based on quasi-arithmetic means and the induced idea, the hesitant fuzzy aggregation operators based on t-norms and t-conorms, the hesitant multiplicative aggregation operators, discuss their relations in detail, and apply them to the enterprise's development planning of strategy initiatives, site

selection, the supplier selection in a supply chain, safety evaluation of work systems, etc.

Chapter 2 mainly investigates the distance, similarity, correlation, entropy measures and clustering algorithms for hesitant fuzzy information. We first introduce a series of distance measures for HFSs, based on which the corresponding similarity measures are given. Then we investigate the distance and correlation measures for HFEs, and discuss their properties in detail. We introduce the concepts of entropy and cross-entropy for hesitant fuzzy information, and analyze the relationships among the proposed entropy, cross-entropy, and similarity measures. We also introduce some correlation coefficient formulas and use them to calculate the degrees of correlation among HFSs aiming at clustering different objects. Moreover, we give the hesitant fuzzy agglomerative hierarchical clustering algorithm, the hierarchical hesitant fuzzy K-means clustering algorithm which takes the results of hierarchical clustering as the initial input, and also introduce a minimal spanning tree algorithm-based clustering technique to make clustering analysis of HFSs via some hesitant fuzzy distances. The applications of the algorithms in energy policy evaluation, medical diagnosis, supplier selection of manufacturing enterprise, software evaluation and classification, and tourism resources assessment, etc., are demonstrated.

Chapter 3 focuses on group decision making with hesitant preference relations. We introduce the concepts of hesitant fuzzy preference relation and multiplicative preference relation, by using them we give two group decision making approaches. Based on the multiplicative consistency and the acceptable multiplicative consistency, we establish two algorithms to improve the inconsistency level of a hesitant fuzzy preference relation, and investigate the consensus of group decision making based on hesitant fuzzy preference relations. We introduce two regression methods that transform hesitant fuzzy preference relations into fuzzy preference relations, which depend on the additive transitivity and the weak consistency respectively. Based on two principles (i.e., α-normalization and β-normalization), we develop a hesitant goal programming model to derive priorities from hesitant fuzzy preference relations and some consistency measures of hesitant fuzzy preference relations. Additionally, we introduce a hesitant fuzzy programming method to derive priorities from a hesitant multiplicative preference relation in AHP-hesitant group decision making.

Chapter 4 is devoted to the multi-attribute decision making models with hesitant fuzzy information. Based on the TOPSIS and the maximizing deviation method, we give an approach for solving the multi-attribute decision making problems, in which the evaluation information provided by the decision maker is expressed in HFEs and the information about attribute weights is incomplete. By using the concepts of hesitant fuzzy concordance and hesitant fuzzy discordance which are based on the given scores and the deviation degrees, we introduce a hesitant fuzzy ELECTRE I method and apply it to solve the multi-attribute decision making problem with hesitant fuzzy information. With the incomplete weight information, we define the satisfaction degree of an alternative, based on which several optimization models are derived to determine the weights of attributes, and then develop an interactive method based on some optimization models for the multi-attribute decision making problems under hesitant fuzzy

environments. Moreover, all the given methods are illustrated and used in some practical applications.

This book can be used as a reference for researchers and practitioners working in the fields of fuzzy mathematics, operations research, information science, management science and engineering, etc. It can also be used as a textbook for postgraduate and senior-year undergraduate students.

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Contents