Preface

Statistical decision-making helps us learn to analyze data and use methods of statistical inference in making business decisions. Statistical inference is the process of drawing conclusions about the population based on information from a sample of that population. Statistical inference methods include point and interval estimations, hypothesis testing, clustering, etc. However, descriptive statistics is used in the inferential statistics as an input to conclude about the population.

Fuzziness is a kind of uncertainty that everything is a matter of degree. The sources of this uncertainty may be the incomplete information or insufficient data. Fuzzy statistics is a complementary statistics in these cases where classical statistics has almost nothing to do. In this book, fuzzy decision-making techniques are presented by their theory and applications. Fuzzy interval estimation, fuzzy hypothesis testing, fuzzy regression and correlation, and fuzzy process control are some of these techniques involved in this book.

The first chapter presents an introduction to fuzzy decision-making. The authors survey the literature of fuzzy statistics and fuzzy statistical decision-making and present the results by graphical illustrations.

The second chapter presents discrete fuzzy probability distributions. The fuzzy expectation theory is introduced. Fuzzy Bayes theorem, fuzzy binomial distribution, and fuzzy Poisson distribution are derived and numerical examples are given.

The third chapter presents continuous fuzzy probability distributions. Fuzzy continuous expectation, fuzzy continuous uniform distribution, fuzzy exponential distribution, fuzzy Laplace distribution, fuzzy normal distribution, and fuzzy log-normal distribution are developed and numerical examples are given.

The fourth chapter explains the generalized Bayes theorem in handling fuzzy a priori information and fuzzy data. Individual measurement results also contain another kind of uncertainty, which is called fuzziness. The combination of fuzziness and stochastic uncertainty calls for a generalization of Bayesian inference, i.e., fuzzy Bayesian inference.

The fifth chapter converts the classical central tendency measures to their fuzzy cases. Fuzzy mean, fuzzy mode, and fuzzy median are explained by numerical examples. Fuzzy frequency distribution is another subtitle of this chapter. Classical graphical illustrations are examined under fuzziness. A numerical example for each central tendency measure is given.

The sixth chapter develops the fuzzy versions of classical dispersion measures namely, standard deviation and variance, mean absolute deviation, coefficient of variation, range, and quartiles. Initially it summarizes the classical dispersion measures and then develops their fuzzy versions for triangular fuzzy data. A numerical example for each fuzzy dispersion measure is given.

The seventh chapter introduces a new approach for the estimation of a parameter in the statistical models, based on fuzzy sample space. Two basic concepts of the point estimation, i.e., sufficiency and completeness, are extended to the fuzzy data case. Then, the unbiased estimator and the uniformly minimum variance unbiased (UMVU) estimator are defined for such situations. The properties of these estimators are investigated, and some procedures are provided to obtain the UMVU estimators, based on fuzzy data.

The eighth chapter is on fuzzy confidence regions. The construction is explained for classical statistics as well as for Bayesian analysis. A numerical example is also given.

The ninth chapter focuses on analyzing the works on fuzzy point and interval estimations (PIE) for the years between 1980 and 2015. In this chapter, the literature is reviewed through Scopus database and the review results are given by graphical illustrations. The chapter also uses the extensions of fuzzy sets such as interval-valued intuitionistic fuzzy sets (IVIFS) and hesitant fuzzy sets (HFS) to develop the confidence intervals based on these sets. The chapter also includes numerical examples to increase the understandability of the proposed approaches.

The tenth chapter generalizes the p-value concept for testing fuzzy hypotheses on the basis of Zadeh's probability measure of fuzzy events. The authors prove that the introduced p-value has uniform distribution over (0,1) when the null fuzzy hypothesis is true. Then based on such a p-value, a procedure is illustrated to test various types of fuzzy hypotheses. Several applied examples are given to show the performance of the method.

The eleventh chapter has two objectives. It critically exposes the most relevant fuzzy linear regression methods and remarks the most relevant actuarial applications of fuzzy regression and also develops one recurrent application: the estimation of the public debt yield curve as a basis for fuzzy financial pricing of insurance contracts.

The twelfth chapter deals with fuzzy correlation and fuzzy nonlinear regression analyses. Both correlation and regression analyses that are useful and widely employed statistical tools are redefined in the framework of fuzzy set theory in order to comprehend relation and to model observations of variables collected as either qualitative or approximately known quantities which are no longer being utilized directly in classical sense. While extension principle based methods are utilized in the computational procedures for fuzzy correlation coefficient, the distance based methods preferred rather than mathematical programming ones are employed in parameter estimation of fuzzy regression models. Illustrative examples in detail for fuzzy correlation analysis are given.

The thirteenth chapter discusses Interactive Dichotomizer 3 (ID3) algorithm and supervised learning in quest (SLIQ) decision tree algorithm. These algorithms generate fuzzy decision trees. Their performances are tested using simple training sets from the literature.

The fourteenth chapter presents the Shewhart process control techniques under fuzziness. Variable and attribute control charts are extended to their fuzzy versions. Numerical examples are also given.

The fifteenth chapter develops exponentially weighted moving averages (EWMA) and cumulative sum (CUSUM) control charts having the ability of detecting small shifts in the process mean. Numerical illustrations of fuzzy EWMA and CUSUM control charts are also given.

The sixteenth chapter presents a new method to test linear hypothesis using a fuzzy set statistic produced by a set of confidence intervals with non-equal tails. A fuzzy significance level is used to evaluate the linear hypothesis. One-way ANOVA based on fuzzy test statistic and fuzzy significance level is developed. Numerical examples are given for illustration.

The seventeenth chapter summarizes and reviews the fuzzy ANOVA where the collected data considered fuzzy rather than crisp numbers. A real case study is also presented.

The eighteenth chapter presents different types of fuzzy data mining approaches including Apriori-based fuzzy data mining, tree-based fuzzy data mining, and genetic-fuzzy data mining approaches.

We hope that this book will provide a useful resource of ideas, techniques, and methods for the development of fuzzy statistics. We are grateful to the referees whose valuable and highly appreciated works contributed to select the high-quality chapters published in this book. We would also like to thank Prof. Janusz Kacprzyk, the editor of Studies in Fuzziness and Soft Computing at Springer for his supportive role in this process.

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