FUZZY INFORMATION AND DECISION PROCESSES

Edited by

Madan M. GUPTA

and

Elie SANCHEZ

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Edited by

Madan M. GUPTA
Cybernetics Research Laboratory
University of Saskatchewan
Saskatoon, Canada

and

Elie SANCHEZ
Service Universitaire de Biomathématiques
Faculté de Médecine
Marseille, France

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FOREWORD

Since the publication of the two books, "Fuzzy Automata and Decision Processes" (North Holland, 1977) and "Advances in Fuzzy Set Theory and Applications" (North Holland, 1979), there has been a rapid expansion in the theoretical development of fuzzy set theory and its many applications to the hard and soft sciences.

In spite of traditional analysis based upon conventional mathematics, the human thought process has played, and will continue to play, a very important role in knowledge representation and decision analysis. Examples may be found in engineering, medicine, psychology and many other fields where fuzzy information and approximate reasoning are essential to decision making.

These two volumes entitled, "Fuzzy Information and Decision Processes" and "Approximate Reasoning in Decision Analysis" truly reflect the progress made over the last seventeen years since the inception of the fuzzy concepts in 1965. Over 130 world researchers from 21 different countries have reported their research in these two volumes. This international cooperation and exchange of scientific information is a sign of the good and increasing health of this field of Fuzzy Information and Decision Processes.

Peter N. Nikiforuk, Ph.D., D.Sc.
Dean of Engineering
University of Saskatchewan
Saskatoon, Saskatchewan
Canada S7N 0W0

ACKNOWLEDGEMENTS

These two volumes entitled, "Fuzzy Information and Decision Processes" and "Approximate Reasoning in Decision Analysis" represent the work of over one hundred and thirty individuals from twenty one different countries. It is gratifying to acknowledge the devotion of these individuals who have contributed to the exploration of these new theories, to the development of new areas of applications, to the stimulation of the advancement of scientific information, and to the reinforcement of international cooperation in this important field of human decision processes. The Editors record their appreciation to Miss E. Nikiforuk, our research assistant, and Miss Freda Peil, our secretary, who were very helpful during all the editorial phases of these two volumes.

Madan M. Gupta

Elie Sanchez

(Editors)

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PREFACE

The subject of information processing and decision analysis, especially using the data arising from human thought and cognition process, has occupied a prominent place in the information processing literature since the inception of Fuzzy Set Theory in 1965. As a result, during the last fifteen years engineering journals as well as those in the social, biological, and medical sciences, have devoted increasing space to articles dealing with the analysis of fuzzy data. Many scientists, mathematicians and social scientists have contributed to this progress but the literature on such a diversified subject is widely scattered. During the decade 1970 - 1980, an important new approach to decision analysis came into prominence. This approach has appeared in the publication of the previous two volumes entitled, "Fuzzy Automata and Decision Processes" (North Holland, 1977) and "Advances in Fuzzy Set Theory and Applications" (North Holland, 1979). Since then, there has been a rapid growth in this theory with many more new applications in different fields. In the present two volumes entitled, "Fuzzy Information and Decision Processes" and "Approximate Reasoning in Decision Analysis" an attempt has been made once again to incorporate the recent advances in both theory and applications.

Initially the project was designed only for one volume, but overwhelming response from the researchers representing over 21 countries forced the editors to enlarge the project to two volumes. The volume entitled, "Fuzzy Information and Decision Processes" contains 45 articles by sixty-three contributors from sixteen different countries.* The second volume entitled "Approximate Reasoning in Decision Analysis" contains 44 articles by seventy-four contributors from seventeen different countries.** Thus the total number of contributors are over 130 from 21 different countries around the world. It is unfortunate that over 50 articles, some of which were of excellent nature, could not be included in these two volumes because of a large constraint on the size.

Initially the proposal was to divide each volume into three parts: introduction, advances in theory, and advances in applications. Some last minute editorial changes were made and each volume was divided according to certain topics. The following is a brief description of each volume with descriptive keywords.

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* Austria, Belgium, Canada, People's Republic of China, Denmark, France, West Germany, Italy, Japan, Lebanon, The Netherlands, Poland, Romania, Spain, U.K. and U.S.A.

** Austria, Belgium, Brazil, Canada, People's Republic of China, Czechoslovakia, France, West Germany, Hungary, Italy, Japan, Poland, Spain, U.K., U.S.A. and U.S.S.R.

Fuzzy Information and Decision Processes

Part One: Fuzzy Information and Entropy (6 papers)

Keywords: Fuzzy Entropy, fuzzy measures, ordering, subjective entropy, probabilistic set, vagueness, generalized information, lattice evaluation, and separation.

Part Two: Fuzzy Probability, Fuzzy Integrals and Belief Functions (6 papers)

Keywords: Fuzzy measures, probability of fuzzy events, fuzzy numbers, fuzzy Lebesque measure, theory of evidence, subjective probability, degree of belief, and membership function.

Part Three: Fuzzy Mathematical Structures (7 papers)

Keywords: Aggregation, vagueness, relational algebra, L-matrices, category, fuzzy graphs, possibility, lattice theory, fuzzy set structure, ordinal numbers, fuzzy ordering, and fuzzy cardinals.

Part Four: Formalization Of Uncertainty (7 papers)

Keywords: Formalization of vagueness, possibility, plausibility, belief, Dempster's rule, fuzzy reasoning, random sets, possibility distributions, fuzzy set operations, homomorphisms, random vectors, and computer security.

Part Five: Fuzzy Optimization Methods (4 papers)

Keywords: Mathematical programming, fuzzy optimization, topos, and multistage decision making.

Part Six: Aggregation, Multicriteria, Modelling and Fuzzy Ordering (6 papers)

Keywords: Linguistic variables, aggregate planning, multicriteria modelling, social systems, management, fuzzy outranking, scoring methods, interval scale, and preference.

Part Seven: Fuzzy Databases and Question-Answering (4 papers)

Keywords: Database, possibility distribution, fuzzy predicate, question-answering, similarity relations, analogical inference and information retrieval.

Part Eight: Fuzzy Systems and Fuzzy Logic Controllers (5 papers)

Keywords: Fuzzy logics, fuzzy controllers, linguistic controllers, fuzzy systems, multivalued logics, adaptive algorithms, pansystems, and pansymmetry.

Approximate Reasoning in Decision Analysis

Part One: On Membership Functions (3 papers)

Keywords: Membership function, stochastic fuzzy set, relative A-ness, and membership degree.

Part Two: Composite Fuzzy Relations (5 papers)

Keywords: Composite relations, group decision, fuzzy relational equations, L-fuzzy set, LSG operator, fuzzy matrix, eigen fuzzy set, and lattice module-homomorphism.

Part Three: Fuzzy Logic and Inference (5 papers)

Keywords: Fuzzy conditional inference, fuzzy modus ponens, fuzzy modus tollens, syllogism, classification, medical diagnosis, fuzzy switching, and fuzzy functions.

Part Four: Classifications and Similarity Measures (9 papers)

Keywords: Classification algorithms, linguistic variables, fuzzy vectors, feature extraction, fuzzy scale, pseudo-interval, similarity measures, nth level fuzzy sets, vector valued fuzzy sets, texture analysis, linguistic descriptors, speech processing, automatic learning, and neural systems.

Part Five: Expert Systems and Medical Diagnosis (7 papers)

Keywords: Medical diagnosis, expert systems, possibility theory, Dempster and Shafer's theory, damage assessment, computer aided diagnosis, fuzzy heuristics, ECG classification, fuzzy linguistics, fuzzy utilities, and Chinese medicine.

Part Six: Psychological Measurements and Human Behavior (4 papers)

Keywords: Behavior modification, cognitive modelling, linguistic descriptors, psychological measurements, earthquake, and civil evacuation.

Part Seven: Approximate Reasoning and Decision Analysis (7 papers)

Keywords: Linguistic approach, natural language processing, approximate

reasoning, linguistic instructions, artificial intelligence, operational research, management, fuzzy decision making, linguistic proposition, dynamic conflict resolution, creative decision, catastrophes, creative decisions rank correlation, and complex planning.

Part Eight: Fuzzy Clustering Algorithms (4 papers)

Keywords: Clustering, possibilistic manipulation, cluster validity, weather forecasting, water pollution control, management practice, and fuzzy hierarchical models.

From the keywords recorded under each heading, it may be noted that the classification is not exclusively devoted to a single topic, but rather there is a considerable amount of overlap. This overlapping of topics constitutes a logical step for such a growing and diversified field. Both of the volumes cover a wide range of theoretical development as well as applications. This diversification of applications indicates that scientists are getting more and more aware of the fact that in real world problems uncertainty arising from human cognition and thought process is a matter of degrees and must be treated rather using a nonconventional approach. In a wide range of problems dealing with hard and soft sciences, it is now getting clear that fuzzy set theory, possibility theory and related notions provide very natural and appropriate tools to model uncertainty.

Readers would note from these two volumes that many new and young researchers are emerging to work in this field. There are many fuzzy working groups that have been formed during the past decade at national and trans-national levels. In the People's Republic of China alone over 250 researchers are engaged working in this field; and a small sample of their work has been reported in these two volumes. Other notable working groups are in India, Japan, North America, U.K., Europe and USSR. And it is gratifying to publish a small amount of their selected work in these two volumes.

Increasingly, the progress of science and technology involves the interaction of ideas from different parts of the world and merging of results from different disciplines. The editors wish to quickly publish

these ideas and results which are evolving at an exponential rate. For this reason there are some errors, both in mathematics and english, which could not be corrected.

The editors sincerely hope that these two volumes will complement other works that have appeared and are appearing in scattered scientific journals and other publications.

June 30, 1982

Madan M. Gupta

Elie Sanchez

Editors

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174 - 35

LIST OF BOOKS AND JOURNALS ON FUZZY SYSTEMS

1. D. Dubois and H. Prade (1979): "Fuzzy Sets and Systems: Theory and Applications", Academic Press.

2. M.M. Gupta (Editor), G.N. Saridis and B.R. Gaines (Assoc. Editors) (1977): "Fuzzy Automata and Decision Processes", North-Holland.

3. M.M. Gupta (Editor), R.K. Ragade and R.R. Yager (Assoc. Editors) (1979): "Advances in Fuzzy Set Theory and Applications", North-Holland.

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12. C.V. Negoita and D.A. Ralescu (1975): "Applications of Fuzzy Sets to Systems Analysis", Birkhauser Verlag.

13. L.A. Zadeh, K.S. Fu, K. Tanaka and M. Shimura (eds) (1975): "Fuzzy Sets and Their Applications to Cognitive and Decision Processes", Academic Press.

14. International Journal of Fuzzy Sets and Systems, North-Holland.

15. Journal of Fuzzy Mathematics, Huazhong (Central China) University of Science and Technology, Wuhan, Hubei, People's Republic of China.

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IN MEMORIAM
PROFESSOR JOSEPH KAMPÉ DE FÉRIET

Membre correspondant de l'Académie des Sciences.
Professeur honoraire à la Faculté des Sciences de Lille
Officier de la Légion d'honneur
Commandeur de l'ordre national du mérite.

It was with deep regret that we learned of Professor J. Kampé de Fériet's death on April 6, 1982, at Lille, France, in his eighty-ninth year.

The scientific community will remember him for the variety of great contributions made during his long and distinguished career. He was professionally active until a few months before his death, in fact, the article entitled "Interpretation of membership functions of fuzzy sets in terms of plausibility and belief" was in press for publication in the book *Fuzzy Information and Decision Processes* (edited by M. Gupta and E. Sanchez and published by North-Holland, 1982) at the time.

We had the good fortune to become one of Professor Kampé de Fériet's students in 1970 in Lille. At that time, though in his seventy-seventh year, he devoted virtually all his time to research rather than writing textbooks on history of mathematics. He paid particular attention to his new-found theory of generalized information. Professor Kampé de Fériet once explained carefully to us that his research activities followed a logical pattern: from early interest in mechanics, to probability, to statistical mechanics and finally to information theory. The concepts of probability and information (semantic information) were at the center of his philosophical discussions, and semantic mathematics, through his investigation of semantic information, has been one of his principal concerns.

After learning of Professor Zadeh's approach to meaning representation using the concept of fuzziness and Professor Shafer's work on the mathematical theory of evidence using the upper and lower probabilities of A. Dempster, Professor Kampé de Fériet studied these related fields and expressed his views on the directions of this research in his last paper. We firmly believe that this work will provide inspiration for workers in the field for many years to come.

Having just made some impression of our professional admiration of Professor Kampé de Fériet, we hasten to point out that this is not to be considered as summary of his life and work which will be detailed elsewhere. Rather we hope it will be viewed as a symbol of the love and affection we have for this great man; as is so often the case, such expressions are forthcoming only in moments of sadness and regret such as this.

Our professor will be affectionately remembered by all his students and colleagues not only as a model scientist but also as a teacher with strong influences. Whether African bee honey and bitter chocolate really extended his powers, we have yet to tell but we remember such stories and our heart smiles.

With his children, Father Lambert, O.S.B., Mr. and Mrs. Marc Kampé de Fériet, Mr. and Mrs. Michel Kampé de Fériet and his grandchildren Annick Kampé de Fériet, Mr. and Mrs. Dominique Morel, we share the pain of losing him.

Hung T. Nguyen
Department of Mathematical Sciences
New Mexico State University
Las Cruces, New Mexico (U.S.A.)

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The editors deeply regret the death of Professor J. Kampé de Fériet. He will be remembered by the scientific community for the excellence in research that he achieved during his life time. The paper included in this volume truly reflects his dedication to scientific research. He wrote this paper entitled "Interpretation of Membership Functions of Fuzzy Sets in Terms of Plausibility and Belief" in French, which was translated into English by Dr. E. Sanchez.

M.M. Gupta
E. Sanchez
- Editors.

CONTENTS

FOREWORD vii

ACKNOWLEDGEMENTS viii

PREFACE ix

IN MEMORIAM: PROFESSOR JOSEPH KAMPE DE FERIET
HUNG T. NGUYEN xvii

PART ONE: FUZZY INFORMATION, AND ENTROPY

1. From Measures of Fuzziness To Booleanity Control
Teresa Riera and Enric Trillas 3

2. On Some Algebraic Aspects of the Measures of Fuzziness
Aldo De Luca and Settimo Termini 17

3. Ordering Via Fuzzy Entropy
Antonio Di Nola and Aldo G.S. Ventre 25

4. Ambiguity Based On the Concept of Subjective Entropy
Kaoru Hirota 29

5. Aspects for the Evaluation of Decision Situations
Ernest Czogała, Siegfried Gottwald and Witold Pedrycz 41

6. Complementation and Information on the Separating Power of a Fuzzy Set
Christiane Dujet 51

PART TWO: FUZZY PROBABILITY, FUZZY INTEGRALS, AND BELIEF FUNCTIONS

7. A Theory of Fuzzy Measures: A Survey
Erich Peter Klement 59

8. Some Problems In Fuzzy Probability
Cheng Zhaozhong and Liu Dsosu 67

9. The Structure of Fuzzy Lebesgue Measure
Zi-Xiao Wang 71

10. On Fuzzy Measure and Fuzzy Integral
S.T. Wierzchoń 79

11. Subjective Probability and Fuzzy Measures
Philippe Smets 87

12. Interpretation of Membership Functions of Fuzzy Sets in Terms of Plausibility and Belief
J. Kampé de Fériet 93

PART THREE: FUZZY MATHEMATICAL STRUCTURES

13. Modelling Vagueness
Heinz J. Skala 101

14. Approach to an Axiomatic Study on the Fuzzy Relations on Finite Sets
Jean-Pierre Olivier and Dany Serrato 111

15. A Generation of Fuzzy Category and Constructions of Invertible Elements in the Fuzzy Category
Ying-ming Liu 117

16. Graphs and Fuzzy Graphs
Umberto Cerruti 123

17. A $\tilde{f}$-Sets Universe $\tilde{V}$
Odile Botta and Marianne Delorme 133

18. Between Fuzzy Set Theory and Boolean Valued Set Theory
Zhang Jinwen 143

19. Cardinal and Ordinal Theories About Fuzzy Sets
Nicole Blanchard 149

PART FOUR: FORMALIZATION OF UNCERTAINTY

20. Some Foundational Problems in the Formalization of Vagueness
Guglielmo Tamburrini and Settimo Termini 161

21. On Several Representations of an Uncertain Body of Evidence
Didier Dubois and Henri Prade 167

22. Foundations for a Theory of Possibility
Robin Giles 183

23. Possibility Measures and Related Topics
Hung T. Nguyen 197

24. Characterizations of N-Ary Fuzzy Set ,Operations Which Induce Homomorphic Random Set Operations
I.R. Goodman 203

25. Treating a Fuzzy Subset as a Projectable Random Subset
Wang Pei-Zhuang and Elie Sanchez 213

26. Possibility Theory: As A Tool for Preliminary Analysis of Computer Security Systems
David C. Rine 221

PART FIVE: FUZZY OPTIMIZATION METHODS

27. Fuzzy Mathematical Programming
J.L. Verdegay 231

28. New Utilization of Fuzzy Optimization Method
Ghassan Kabbara 239

29. On Fuzzy Optimization
C.V. Negoita and A.C. Stefanescu 247

30. Multistage Decision Processes in a Fuzzy Environment: A Survey
Janusz Kacprzyk 251

PART SIX: AGGREGATION, MULTICRITERIA MODELLING, AND FUZZY ORDERING

31. The Performance of Fuzzy Algorithm Models for Aggregate Planning Under Differing Cost Structures
Dan B. Rinks 267

32. Fuzzy Set Methodologies in Multicriteria Modelling
Keith W. Hipel 279

33. A Method of Multicriteria Analysis
Emilio Freire and Anibal Ollero 289

34. Interactive Identification of Fuzzy Outranking Relations in a Multicriteria Decision Problem
Eiji Takeda 301

35. The Use of Fuzzy Numbers In Decision Analysis
Didier Dubois and Henri Prade 309

36. Choice Theory for Cardinal Scales
S.V. Ovchinnikov 323

PART SEVEN: FUZZY DATABASE AND QUESTION - ANSWERING

37. Freedom-0: A Fuzzy Database System
Motohide Umano 339

38. Some Problems in the Foundations of Fuzzy Set Theory
Maria Nowakowska 349

39. Fuzzy Databases and Their Applications
Billy P. Buckles and Frederick E. Petry 361

40. A Representation of Analogical Inference By Fuzzy Sets And Its Application to Information Retrieval System
Kiyohiko Nakamura and Sosuke Iwai 373

PART EIGHT: FUZZY SYSTEMS AND FUZZY LOGIC CONTROLLERS

41. Control of a Cement Kiln by Fuzzy Logic
Lauritz P. Holmblad and Jens-Jorgen Østergaard 389

42. A Mathematical Theory of Fuzzy Systems
Michel de Glas 401

43. An Expression for Fuzzy Controller
Wei-Min Cheng, Shou-Ju Ren, Chiu-Feng Wu, Tse-Hsing Tsuei 411

44. Heuristic Approach to Pump Operations Using Multi-Valued Logic
Masasumi Kokawa 415

45. Pansystems Methodology: A Transfield Investigation of Generalized System-Transformation-Symmetry
Wu Xuemou 423

PART NINE: BIOGRAPHICAL INFORMATION

46. Biographical Information about the Editors and Contributing Authors 437

TABLE OF CONTENTS OF "APPROXIMATE REASONING IN DECISION ANALYSIS", EDITED BY M.M. GUPTA AND E. SANCHEZ, NORTH-HOLLAND, 1982 449

PART ONE

FUZZY INFORMATION AND ENTROPY

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