New Frontiers of Decision Making for — the — Information Technology Era

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New Frontiers of Decision Making for ———— the ———— Information Technology Era

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BIO SKETCH

Po-Lung Yu, Carl A. Scupin Distinguished Professor of the University of Kansas and Distinguished Professor of the National Chiao-Tung University, Taiwan, was raised in Taiwan, further educated and trained in USA. He earned BA--*International Business* (1963) from the National Taiwan University, and Ph.D.--*Operations Research and Industrial Engineering* (1969) from the Johns Hopkins University.

Before joining University of Kansas as a Distinguished Professor (1977), Dr. Yu taught at the University of Rochester (1969-73) and the University of Texas at Austin (1973-77). He won awards for outstanding teaching and for research, including the Edgeworth-Pareto Award by the International Society on Multiple Criteria Decision Making (1992).

Professor Yu has published more than ten books and more than one hundred professional articles in the areas of optimal control, differential games, multicriteria decision making, mathematical programming, optimization theory, habitual domains/human software, and competence set analysis. He served as the Area Editor of *Operations Research--Decision Making* (1994-98) and is an Associate Editor of the *Journal of Optimization Theory and Applications*.

Based broadly on dynamic multicriteria optimization, system science, psychology, neural physiology and living philosophy, Dr. Yu created *Habitual Domains*, his system for achieving success in life and business. He is recognized internationally as a remarkable thinker, scholar, teacher and advisor. He has given many speeches around the world, academically and publicly. His audiences of habitual domains, sometimes exceeding thousands of people, include professors, students, corporate executives, ministers, military generals, monks, nuns, house wives, jail prisoners, etc...

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Portrait of P. L. Yu

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PREFACE

Dedication

This volume is dedicated to Po-lung Yu.

The *New Frontiers of Decision Making for the Information Technology Era* is a fitting title for the work of thirty-nine authors, all MCDM (Multiple Criteria Decision Making) researchers and colleagues who have worked very hard to prepare the set of contributions that would not only capture current state of MCDM, but also honor P. L. Yu by offering new problems and new ideas at the frontiers of future MCDM endeavors.

Professor Yu stood at the very beginning of Multiple Criteria Decision Making. In 1969 he started supervising a dissertation on Linear Multiobjective Programming and brought his grateful student, Milan Zeleny, successfully through some of the hardest mathematical challenges of operations research. It was all well worth it. Both careers, of the teacher and his student, have taken off in this new, wonderful and strange area of research they came to call MCDM. Both careers have remained true to MCDM over more than three decades.

Thirty-nine researchers from all over the world, participating in this volume, offer here their work tribute to P. L. Yu's thirty years in MCDM. The young men of the early 70s, breaking all the rules and venturing into uncharted waters of MCDM, have greatly benefited from P. L. Yu's erudite mathematics that helped to put the newly emerging field on secure footing and stable foundations. The set of nondominated solutions, multiple criteria decision making, and the ideal solution, multicriteria simplex method, compromise programming, habitual domains, de novo programming and interactive programming – such were the new words and labels these young men worked with and coined. Even today, these labels still form the foundations of MCDM. When these young men finally met in Columbia, South Carolina, in October 26-27, 1972, they were all there, as was P. L. Yu, and then the Multiple Criteria Decision Making (MCDM) was born.

Thirty years later they can still remember, recall and recreate the work well done. All their basic precepts have survived and even flourished. MCDM was pointed in the right direction. It, as a field, has often wavered, sometimes went in circles, even hit some dead-ends, but always searched vigorously for its own identity. Not all is right with MCDM and more achievement could have been expected after the thirty years of trying. The young men of 1972 are still at it, even in the new millennium, breaking new directions, fighting for new ideas and pushing the envelope of MCDM frontiers.

In the last thirty years, P. L. Yu has produced numerous Ph.D. students at the University of Rochester, University of Texas at Austin, and University of Kansas. Some of them eventually become active researchers working at the very edge of MCDM. Both editors were his Ph.D. students: Milan Zeleny graduated from the University of Rochester, while Yong Shi graduated from University of Kansas. Under P. L. Yu's supervision, Yong Shi's dissertation on Optimal System Design and MC² Linear Programming has attracted more than two dozens of international scholars from five countries. Their theoretical findings based on Yong Shi's work have already applied to many Information Technology and Systems (IT/S) areas, such as information file allocation, telecommunications hub site selection, and data mining.

P. L. Yu and his students are still fighting for MCDM. His work on habitual domains and effective decision-making draws on a number of seemingly disparate ideas, ranging from ancient Chinese wisdom, psychology and neural sciences, all the way to mathematics, strategy and business leadership. He is not satisfied with working on a simple algorithm, improved efficiency or some different formula – that is not what MCDM is or should be about. Professor Yu is striving for a new system of thought, a new paradigm and philosophy, as all MCDM researchers surely should. It has been the conviction of the young men of the South Carolina conference that MCDM is not a simple extension or refinement of operations research, but a new way of thinking, capable of standing on its own, reaching far beyond the rusting toolbox of operations research: all the way into economics, business management and organization, systems sciences and management support systems.

P. L. Yu brought in an excellent background in differential games, moved to multicriteria simplex method and nondominated sets, graduated into compromise programming and ideal solutions and finally tackled the very nature of human decision-making processes. He is the very embodiment of the old scholar dictum: You may start with some math and form, but must finish with substantial philosophy, wisdom and contents. The end must dignify the road taken, not the other way around. The young generation of MCDM prospects has in Professor Yu a worthy and challenging role model to emulate, a path to follow and a life to aspire to. So do all of us, young and old in MCDM, who are still trying to make a difference.

About this volume

The editors have invited a group of well-known international experts in Decision Making from 11 countries and regions and asked them to prepare individual chapters for the book exploring the frontiers of decision making in the era of Information Technology and Systems (IT/S). All of their contributions are

original, prepared specifically for this volume and not published elsewhere. This book is intended to serve as a research source, scientific reference, business-support source and a book of student readings that will appeal to a larger international audience. To our knowledge, there is no competitor that would be preparing similar book for the market.

Our goal is to inform IT/S users and developers of the advances in decision making and decision-making support that empower and enable information technology in the direction of productivity and effectiveness of decision making in business.

The multi-author work pushes decision-making frontiers in close realignment with the new technology. The nature of decision making has changed: (i) *multiple-criteria balancing* has become an integral part, (ii) the number of decision makers and decision-making networks has increased, and (iii) Information Technology enhances business decision support. The book covers a number of cutting-edge developments in decision-making areas: Behavioral Issues in Decision-Making, Multiple Criteria and Decision Support Systems, Objective Space Analysis, Risk and Efficiency Management, Tradeoffs Analysis, Data Envelopment Analysis, Multiple Criteria and System Engineering, and Multiple Criteria Applications.

In Part 1, Behavioral Issues in Decision Making, *Wuli-Shili-Renli System Approach and Its Practice in China* by Jifa Gu, describes the origin, philosophy, concept, process and principles of the “Wuli-Shili-Renli” System Approach (WSR). Recent real-life applications of WSR in the fields of evaluation, water-resources management, regional development, safety and risk analysis and information systems are introduced to show the significance of WSR.

Stanley Zionts offers *Some Thoughts on Multiple Criteria Decision Making for Ordinary Decisions* applying MCDM to day-to-day, ordinary decisions for the man in the street.

Two papers are included in Part 2, Multiple Criteria and Decision Support Systems. In the first paper, *A Decision Support System for Incorporating Competencies of A Software Company*, H. L. Li and J. J. Shuai propose a decision support system to assist a software company in incorporating the competence sets of its subsidiaries in order to maximize the total benefit of the whole group. The databases contain the skills required for developing product, the existing skills, and the costs for learning new skills, while the model base is a mixed 0-1 linear program.

Minghe Sun and Ralph E. Steuer, in *Quad Tree Data Structures for Use in Large-Scale Discrete Alternative Multiple Criteria Problems*, address the problem of identifying, storing, and retrieving nondominated criterion vectors

with a quad tree structure in support of procedures for solving multiple criteria problems.

In Part 3, Objective Space Analysis, we start with the *Vector-Valued Minimax Theorems in Multiple-criteria Games* by Tamaki Tanaka. This paper considers multiple-payoff games as well as more general partial orderings on vector spaces using concepts of cone extreme point and nondominated solutions.

Harold P. Benson and G. M. Boger continue with the analysis of the outcome space in *Analysis of An Outcome Space Formulation of the Multiplicative Programming Problem*, dealing with the multiplicative programming problems. They undertake mathematical derivations and analyses of several properties of a common outcome space, looking for a finite algorithm for finding a strict local optimal solution for the polyhedral case of the outcome space problem.

In *Quadratic Pareto Race*, Pekka J. Korhonen and G. Y. Yu present a dynamic and visual “free-search” type of decision support system, “Quadratic Pareto Race”, which enables a decision maker to freely search any part of the efficiency frontier of a multiple objective quadratic-linear programming problem by controlling the speed and direction of motion.

In Part 4, Risk and Efficiency Management, Guenter Fandel presents *Managerial Disposition Efficiency and Performance Efficiency in Large-scale Production Projects*, elaborating interdependencies between network-based planning in the case of large-scale projects and activity-analytical production aspects of such processes. Applying dynamic activity analysis, the networks can be evaluated in respect of their efficiency in consuming resources.

The Art and Science of Risk Assessment and Management, by Yacov Y. Haimes, addresses some philosophical aspects of the process of risk assessment and management. It explores its qualitative and quantitative dimensions, multiobjective nature, the critical human dimension, and the centrality of the extreme and rare.

In Part 5, Tradeoff Analysis in Decision Making, Milan Zeleny presents a discourse on *The Elimination of Tradeoffs in Modern Business and Economics*, describing the need for tradeoff elimination on the part of producers and service providers. The MCDM role in tradeoff elimination, as an integral part of the New Economy and its new rules and preferences, is discussed.

In *Time-Varying Tradeoffs in Multiobjective Dynamic Programming*, Duan Li considers multiobjective dynamic optimization problems with general separable structure terms of multiobjective dynamic programming. Unless the vector-valued objective function is of a stagewise additive form, the optimal

tradeoffs among various performance indices are time-varying as the system evolves along a noninferior trajectory. This paper further shows that the time-varying tradeoffs in multiobjective dynamic programming are history-dependent.

Oleg I. Larichev, in *Qualitative Comparisons of Multicriteria Alternatives*, argues that from the psychological point of view, operations of information elicitation have different complexity for human beings. The difficulties of comparison for two multicriteria alternatives depend on how different the evaluations of the alternatives are on the criteria. When two alternatives differ on several criteria, the operation of comparison is much more difficult for the decision maker.

In Part 6, Data Envelopment Analysis, Hirotaka Nakayama, T. Tanino and Y. Yun start with *Generalized Data Envelopment Analysis and Its Application*, dealing with the Data Envelopment Analysis (DEA), developed by Charnes, Cooper and Rhodes in 1978. A generalized DEA (GDEA) model including CCR model, BCC model and FDH model as special cases is described along with several theoretical properties for multiple criteria decision making problems.

In *Evaluating Productive Performance under Uncertainty: Combining Data Envelopment Analysis, Mean-Variance Analysis and Multi-Factor Risk Models*, Thierry Post and Jaap Spronk present a new technique for performance evaluation under uncertainty that combines the best of the Data Envelopment Analysis, Mean-Variance Analysis and Multi-Factor Risk models. The proposed approach is illustrated using a real-life application for European commercial banks.

C. I. Chiang and Gwo-Hshiung Tzeng, in *A Multiple Objective Programming Approach to Data Envelopment Analysis*, propose a new efficiency measure in the Data Envelopment Analysis: every efficiency achievement is measured by one maximized objective, while a set of common multipliers, input and output weights are handled by fuzzy multiple objective programming. This new approach is comparatively suitable to a problem with a large number of DEAs.

In Part 7, Multiple Criteria System Engineering, K. S. Park, K. J. Kim and Herbert Moskowitz, in *Multi-Response Surface Optimization and Multi-Objective Optimization: Relationships and Directions*, address simultaneous consideration of multiple response characteristics, called a multi-response surface problem. They note that multi-response surface optimization (MRO) can be viewed as a multi-objective optimization (MOO) and that many techniques developed in MOO can be well utilized to deal with MRO problems.

Yong Shi and Xiaowo Tang present *A State-of-the-art of MC² Linear Programming*, solving decision-making problems with multiple criteria and multiple resource availability (discrete) levels. The topics covered include MC² linear programming, optimal system design, integer MC² linear programming and transportation model, fuzzy MC² linear programming, and their duality theory.

Multiplicative Ratings for The AHP by Antonie Stam and A. P. D. Silva explores the properties of the multiplicative variant of Analytic Hierarchy Process (AHP). The multiplicative AHP (MAHP) differs from the original AHP in that the aggregation of pairwise preference judgments is multiplicative, rather than additive. This paper also studies the extent, in practice, of the difference between these two methods.

In Part 8, Multiple Criteria Applications, S. L. Liu, Shouyang Wang and K. K. Lai deal with *Multiple Criteria Decision Making Models for Competitive Bidding*. They survey the progress of competitive bidding based on MCDM methods, including some new approaches proposed in recent years.

Multiple Objective Linear Programming to Analyse and Classify Business Information by C. H. Lin, K. Siddiqui and Yi-Hsin Liu develops a multiple objective linear programming model dealing with the behavior patterns from business information. This approach has a great impact on object recognition problems in information systems.

Finally, Heeseok Lee, J. Lee, M. H. Sohn, and Yong Shi present *From Enterprise Network to Network Enterprise: Another Perspective of Multiple Criteria Decision Making for Building Corporate Information System*. Enterprise network is an important component in corporate information system. This paper uses MCDM to develop a network enterprise that is called Potential Analysis Methodology as a tool in information system design.

On behalf of the thirty-nine authors and the entire MCDM community worldwide, the editors would like to thank Professor P. L. Yu for his many fruitful and challenging contributions in the area of MCDM, with the hope of many more still to come. Happy sixtieth birthday, P. L. Yu!

Yong Shi and Milan Zeleny
July 2000

CONTENTS

Portrait of P. L. Yu	v
Bio-sketch of P. L. Yu	vii
Preface	ix
Contents	xv
 <i>Part 1: Behavioral Issues in Decision Making</i>	 1
Chapter 1 Wuli-Shili-Renli System Approach and Its Practice in China <i>J. F. Gu</i>	3
Chapter 2 Some Thoughts about Multiple Criteria Decision Making for Ordinary Decisions <i>Stanley Zionts</i>	17
 <i>Part 2: Multiple Criteria and Decision Support Systems</i>	 29
Chapter 3 A Decision Support System for Incorporating Competencies of a Software Company <i>Han-Lin Li and Jia-Jane Shuai</i>	31
Chapter 4 Quad Tree Data Structures for Use in Large-Scale Discrete Alternative Multiple Criteria Problems <i>Minghe Sun and Ralph E. Steuer</i>	48
 <i>Part 3: Objective Space Analysis</i>	 73
Chapter 5 Vector-Valued Minimax Theorems in Multicriteria Games <i>Tamaki Tanaka</i>	75

Chapter 6 Analysis of an Outcome Space Formulation of the Multiplicative Programming Problem	100
<i>H. P. Benson and G. M. Boger</i>	
Chapter 7 Quadratic Pareto Race	123
<i>Pekka Korhonen and Guang Yuan Yu</i>	
Part 4: Risk and Efficiency Management	143
Chapter 8 Managerial Disposition Efficiency and Performance Efficiency in Large-Scale Production Projects	145
<i>G. Fandel</i>	
Chapter 9 The Art and Science of Risk Assessment and Management	157
<i>Yacov Y. Haimes</i>	
Part 5: Tradeoff Analysis in Decision Making	171
Chapter 10 The Elimination of Tradeoffs in Modern Business and Economics	173
<i>Milan Zeleny</i>	
Chapter 11 Time-Varying Trade-offs in Multiobjective Dynamic Programming	196
<i>Duan Li</i>	
Chapter 12 Qualitative Comparisons of Multicriteria Alternatives	207
<i>O. I. Larichev</i>	
Part 6: Data Envelopment Analysis	225
Chapter 13 Generalized Data Envelopment Analysis and Its Application	227
<i>Hirotaka Nakayama, Tetsuzo Tanino and Yeboon Yun</i>	
Chapter 14 Evaluating Productive Performance under Uncertainty: Combining Data Envelopment Analysis, Mean-Variance Analysis, and Multi-Factor Risk Models	249
<i>Thierry Post and Jaap Spronk</i>	

Chapter 15 A Multiple Objective Programming Approach to Data Envelopment Analysis	270
<i>C. I. Chiang and G. H. Tzeng</i>	
Part 7: Multiple Criteria System Engineering	287
Chapter 16 Multi-Response Surface Optimization and Multi-Objective Optimization: Relationships and Directions	289
<i>Kyung Sam Park, Kwang-Jae Kim and Herbert Moskowitz</i>	
Chapter 17 A State-of-the-art of MC ² Linear Programming	304
<i>Yong Shi and Xiaowo Tang</i>	
Chapter 18 Multiplicative Ratings for the AHP	331
<i>Antonie Stam and A. P. D. Silva</i>	
Part 8: Multiple Criteria Applications	347
Chapter 19 Multiple Criteria Decision Making Models for Competitive Bidding	349
<i>S. L. Liu, S. Y. Wang and K. K. Lai</i>	
Chapter 20 Multiple Objective Linear Programming to Analyze and Classify Business Information	373
<i>Chien-Hsiung Lin, Khalid J. Siddiqui and Yi-Hsin Liu</i>	
Chapter 21 From Enterprise Network to Network Enterprise: Another Perspective of Multiple Criteria Decision Making for Building Corporate Information System	389
<i>Heeseok Lee, Jongwon Lee, Myung Ho Sohn and Yong Shi</i>	
List of Selected Publications of P. L. Yu	403
List of Contributors (39 people from 11 countries and regions)	413