Dynamical Aspects in Fuzzy Decision Making

Studies in Fuzziness and Soft Computing

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Yuji Yoshida

Editor

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and 34 Tables

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Preface

The concept of fuzziness, inspired by Zadeh (1965), brings us fruitful results when it is applied to problems in decision making. Recently, problems in fuzzy decision making are getting more complex, and one of the most complex factors is dynamics in systems. Dynamical approach to fuzzy decision making has been proposed by Bellman and Zadeh's celebrated paper "Decision-making in a fuzzy environment" (1970). The idea has developed into fuzzy mathematical programming and has been applied in many fields including management science, operations research, control theory, engineering, systems analysis, computer science, mathematical finance etc. Dynamic programming, advocated in Bellman's book "Dynamic programming" (1957), is one of the most powerful tools to deal with dynamics in systems, and Bellman and Zadeh (1970) has proposed the optimality principle in fuzzy decision making by introducing fuzzy dynamic programming. Fuzzy dynamic programming and fuzzy mathematical programming has been making remarkable progress after they were given life by Bellman and Zadeh's paper (1970).

In this volume, various kinds of dynamics, not only time but also structure of systems, are considered. This volume contains ten reviewed papers, which deal with dynamics in theory and applications and whose topics are potentially related to dynamics and are expected to develop dynamical study in near future. First, fuzzy dynamic programming is reviewed from a viewpoint of its origin and consider its development in theory and applications. Next, the structure of dynamics in systems is considered in relation to fuzzy mathematical programming. Further, some topics potentially related to dynamics are discussed: financial management, fuzzy differential for fuzzy optimization of continuous-time fuzzy systems, and fuzzy ordering in multi-objective fuzzy systems. Finally, a unified approach in fuzzy decision making is developed.

J. Kacprzyk and A.O. Esogbue (*Fuzzy Dynamic Programming: Basic Issues and Problem Classes*) give a brief review of developments on fuzzy dynamic programming. The cases of a deterministic, stochastic, and fuzzy state transitions, and of the fixed and specified, implicitly given, fuzzy, and infinite times termination time are analyzed. This chapter also presents the framework for fuzzy criterion set and fuzzy criterion dynamic programming that is a general tool for dealing with many decision and control situations exemplified by the stochastic reservoir operation and stochastic inventory control models of operations research and engineering, and discusses computational complexity of fuzzy dynamic programs.

S. Iwamoto (*Fuzzy Dynamic Programming in the Stochastic Environment*) reconsiders the decision making models in a fuzzy and stochastic environment in Bellman and Zadeh's paper (1970) from the essential viewpoint of dynamic programming. He shows that a common optimal general policy for minimum criterion has been obtained through three – membership-parametric, history-

parametric and multi-stage stochastic decision tree-table – methods. Further he illustrates that Markov class is not enough for stochastic system with minimum criterion. We see that an invariant imbedding method takes an important part in deriving a recursive formula for stochastic system with nonadditive criterion.

L.F. Sugianto (*Management of Data Uncertainty in Dynamic Programming*) presents an innovative approach to dynamic programming optimization to deal with data uncertainty problem. The proposed approach incorporates confidence measure which enables the utilization of alternative data sources for estimating uncertain data. An algorithm of fuzzy optimization is applied to optimize the spare parts inventory of an electrical power plant, and the technique in this chapter is generally applicable to optimize similar categories of objective functions when fuzzy aggregators can be determined by empirical research.

H.-S. Shih and E.S. Lee (*Discrete Multi-Level Programming in a Dynamic Environment*) present a multi-stage process of the discrete multi-level programming, extending their previous results on fuzzy approach for the multi-level programming, a supervised search procedure to simplify the complex structure. Taking advantage of recursive formulation in the dynamic programming for simplifying the process, the overall satisfaction of decision makers is evaluated through a stage-wise max-min operation and of hierarchical structure as well. Furthermore, an application to resource allocation is developed and a solution procedure is illustrated step by step.

M. Sakawa and I. Nishizaki (*Interactive Fuzzy Programming for Multi-Level Nonconvex Nonlinear Programming Problems Through Genetic Algorithms*) present interactive fuzzy programming through genetic algorithms for multi-level nonconvex nonlinear programming problems with the essentially cooperative decision makers. In the proposed method, mathematical programming problems for obtaining satisfactory solutions concerned in some groups of all the decision makers are successively solved to lead to a global satisfactory solution such that the decision makers at relatively upper levels are esteemed and satisfactory degree of each decision maker balances with those of the others.

M. Inuiguchi and T. Tanino (*Two-Stage Linear Recourse Problems under Non-Probabilistic Uncertainty*) discuss two-stage recourse programming for linear programming problems with uncertain parameters under an assumption that the set of possible realizations of uncertain parameters is known as a polytope. A two-stage recourse problem is formulated from pessimistic viewpoint, and it is shown that this problem is a convex programming problem with respect to the first stage variable vector and a large-scale linear programming problem when all vertices of the polytope representing possible realizations of uncertain parameters are given. A solution algorithm based on a relaxation procedure is proposed.

J. Watada (*Fuzzy Portfolio Model for Decision Making in Investment*) deals with decision making in financial management. He discusses an investment under uncertain environment which is much influenced by the disturbance of social and economical circumstances. He employs the aspiration level on the base of past experiences and knowledge possessed by a decision maker to treat a problem. Portfolio selection problems are formulated as a fuzzy mathematical programming with two objectives to minimize risk and maximize the expected return within a vague aspiration level and a fuzzy goal.

S. Saito, H. Ishii and M. Chen (*Fuzzy Differentials and Deterministic Approaches to Fuzzy Optimization Problems*) consider some types of fuzzy differentials of fuzzy functions which map from open sets in normed spaces to sets of fuzzy sets. There are many results in the field of fuzzy differentials which are strongly related to decision making in continuous fuzzy systems. This chapter introduces some fuzzy differentials which apply a deterministic method to some fuzzy optimization problems.

M. Kurano, M. Yasuda, J. Nakagami and Y. Yoshida (*Order Relations and a Monotone Convergence Theorem in the Class of Fuzzy Sets on R^n*) discuss fuzzy sets on R^n as an extension of fuzzy numbers, concerning with the topics of fuzzy rewards in fuzzy decision processes. This extension is a pseudo order defined by a non-empty closed convex cone and characterized by the projection into its dual cone. Especially a structure of the lattice is presented on the class of pyramid-type fuzzy sets. These results are applied to obtain the limit theorem for a sequence of fuzzy sets defined by the dynamic fuzzy system with a monotone fuzzy relation.

D. Dubois and H. Prade (*Advances in the Egalitarian Approach to Decision-Making in a Fuzzy Environment*) propose a unified approach to decision-making in a fuzzy environment, based on the original idea of Bellman and Zadeh, encompassing fuzzy optimization, fuzzy relational calculus and possibility theory. This approach encompasses the paradigm of constraint-directed reasoning in artificial intelligence and allows for flexible or prioritized constraints. This chapter suggests that the maximin approach to decision is potentially very fruitful both from an algorithmic and application-oriented point of view.

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