学位報告

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主　論　文　の　要　旨

論文題目　Optimization Methods for Decision Making under Uncertainty
（不確実性の下での意思決定のための最適化手法に関する研究）

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論 文 内 容 の 要 旨

Decision making is one of the most familiar problems that everyone always faces, although there are differences in degree. Various decision making problems that we face in real world can very often be formulated as mathematical optimization problem. In addition, such problems often include various ambiguity such as stochastic uncertainty (e.g. weather, stock prices, ...) or subjective uncertainty (e.g. What is sunny day?, What is high stock price?, ...). Therefore, when formulating actual decision-making problems as mathematical optimization problems, unless these uncertainties are dealt with appropriately, there is a danger of adopting poor options. This dissertation describes novel frameworks for the design and analysis of mathematical optimization problems for decision making under uncertainty.

First, we propose an end-to-end framework for each decision making problem. That is the procedure that includes problem formulation, algorithm construction, optimization, and finally selection of an action. In problem formulation step, we employ the multi-objective optimization with randomness (which represents stochastic uncertainty) and fuzziness (which represents subjective uncertainty), as a decision making model. Although, in general, such optimization problems can not be directly optimize due to the uncertainty, we will show that we can use some conventional optimization techniques by reasonable transformation of the problem to deterministic optimization. Then, in algorithm construction step, optimization algorithms are designed for the deterministic optimization problems transformed from the original uncertainty optimization problems. In optimization step, the proposed algorithms run with the interaction to the decision maker and derive a solution that is following to the decision maker's preferences. As the theoretical contribution, we also proved that the optimal solution of the transformed problem has certain Pareto optimality. Furthermore, we demonstrate how the interactive process works through the numerical experiments.

The framework we proposed incorporates the preference structure of the decision maker explicitly into problem and algorithm design. However, in reality in many cases, the decision maker can not explicitly express preferences, that is, preference information can not be used (or can be used only incompletely) in problem formulation and optimization algorithms. Therefore, we also consider a methodology for implementing general optimization under incomplete information. Here, the methodology proposed in this dissertation is not limited to the maximization of the utility function, but it can be used for general function optimization. Specifically, we challenge the task of solving the function minimization problem using only the pairwise comparisons (that is, which one of the two points has lower function value) in the function domain. We propose an optimization algorithm of the block coordinate descent method type for the optimization problem based on noisy pairwise comparison. As a theoretical result, the upper bound of the convergence rate of the proposed method is provided under certain conditions. Under certain settings, this upper bound can be shown to be mini-max optimal with respect to the number of pairwise comparison queries. Moreover, as practice, we conduct the numerical experiments to show the actual performance of our proposal.

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