A Study on Robust Structures Discovery and its Economic Applications : Combination of Algorithm and Simulation

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（ロバスト最適な構造の発見とその経済学的応用の研究

—アルゴリズムとシミュレーションの統合—）

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論 文 内 容 の 要 旨

Solving ill-defined optimization problems, where the actual values of some input parameters are unknown or unknowable, as well as predicting the behavior of algorithms that exhibit sensitive dependence to initial conditions are deemed fundamental issues in several disciplines of science. Such 'butterfly effects' often occur in various scientific fields, including economic and financial problems, where the input parameters are usually estimations and thus error-prone. In this case, the problem solutions overfit the past data used for the parameter estimation, rather than forecasting or solving for the future. The solution results actually in poor performance for the 'true' data. Injecting some randomness in the solving process would be an advantageous feature. Computer simulation, which is an efficient approach used to randomly generate scenarios of the uncertain parameters, enables to better manage the problem uncertainty. In the current thesis, we address the robustness of the solutions of optimization under uncertainty, and of the outputs of sensitive algorithms, by designing a simple simulation module. The role of our simulation process is solely intended to assess robustness, in the sense that the simulation results are encapsulated within two simple robustness criteria that we propose.

Two separate application domains are conveyed in this thesis. First, the financial problem of portfolio optimization is discussed. After examining the robustness of several evolutionary algorithms (EA) using a simple robustness measure computed over multiple sampling scenarios, we turned to integrating our simulation process for robustness assessment into genetic algorithms (GA), the most robust among the examined EAs, through what is commonly known in the metaheuristic field as hybridization. Robustness in this second step is extended to a bi-criteria assessment. Our empirical experiments, where the hybrid GA is compared to well-established paradigms of optimization under uncertainty such as stochastic programming and robust optimization show encouraging results. As the topic of GA application to portfolio optimization is redundantly present in the thesis, a survey of some state-of-the-art approaches on the matter is provided.

The second application of the thesis concerns clustering methods applied to global supply-chain networks, which are generally complex networks. The insight of such application for CO2 emission networks is to find environmentally significant clusters, and thus entry points for international climate change mitigation, as reported in Kagawa et al. (2015) study. However, due to the presence of algorithms sensitive to initialization such as k-means in the body of clustering methods of non-negative matrix factorization and spectral clustering, the yielded cluster assignments are actually sensitive. We employ our bi-criteria simulation module, altered for this problem context, to solve for robust clusterings. Empirical findings of the proposed approach are compared with Kagawa et al. (2015) findings. The environmental implications are reported as well.