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学位論文題目	Effects of Algorithm Design in the Population Behavior of Multiobjective Evolutionary Algorithms. (多目的進化計算における集団行動に対するアルゴリズム設計の効果についての研究)

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論　文　の　要　旨

The thesis presented in this evaluation concerns the analysis of the behavior of Evolutionary Algorithms for solving Multi-Objective optimization problems. Novel methods for analyzing the behavior of this class of algorithms are presented, and these methods are used to understand the performance of current algorithm and present improvements for future applications. Extensive experiments are presented to show the validity of the results investigated in the research.

The use of Evolutionary Algorithms has been a standard approach for solving Multi-Objective optimization problems, and their capacity to find sets of trade-off solutions is well known. However, it is well known that their performance is highly dependent on the parametrization of the algorithm and the characteristics of the problems being solved. Thus, there is an understanding in the field that it is necessary to understand the relationship between algorithm and problem instances, but not many tools, theoretical or otherwise, exist to visualize this relationship. In this context, the current thesis presents theoretical and practical ideas to bridge this gap.

Chapter One outlines the thesis, listing the main contributions and the structure of the work. Chapter Two explains Multi-Objective problems, describing MOEA/D in detail as the main Evolutionary Algorithm for solving this kind of problem, and then reviewing the main tools that exist currently for analyzing the behavior of MOEA/D, including performance indicators, benchmarks, and metrics for analyzing anytime objective space. The chapters establish the lack of proper tools for parameter space analysis.

In Chapter Three, Search Trajectory Networks (STNs) are introduced as a tool that could be used for parameter space analysis. The thesis proposes a new version of STNs for multi-objective optimization problems. An experimental case study shows that the proposed method can be used to compare different evolutionary algorithms.

Chapter Four extends the proposed Multi-Objective STNs by introducing a methodology that uses this method to perform automatic configuration of the MOEA/D algorithm. In Chapter Five, this Methodology is experimentally validated on two different case studies. The automatically configured algorithms show superior performance in benchmark problems, and it is shown that the proposed methods can be used to visualize and understand the behavior of the algorithms on the parameter space. Chapter Six extends the analysis of the proposed methods to a set of benchmarks based on real world problems, showing that the proposed methodology has practical as well as theoretical applications.

Chapter Seven concludes the thesis and draw directions for future work.

審　査　の　要　旨

【批評】

Evolutionary Algorithms for Multi-Objective Problems are effective, but highly dependent on the characteristics of the problem and the configuration of the algorithm. To solve this problem, methods to analyze and understand the algorithm performance is necessary. This thesis proposes new tools for understanding the population behavior of Multi-Objective Evolutionary algorithms by using Search Trajectory Networks. Using indicators based on the Search Trajectory Network graph, a methodology for the automatic configuration of MOEA/D is also proposed. The performance of these methods is validated on benchmarks based on synthetic and real world problems.

The Evolutionary Computation community has for a long time been claiming for higher transparency and understandability of its algorithms. Although Evolutionary Computation algorithms are efficient, they are still black boxes, and this limits their ability to be used in several contexts. The method proposed by this thesis addresses this problem by demonstrating how to better understand the behavior of not only the algorithm as a whole, but also the individual components that compose the algorithm. This will allow for future improvements of Evolutionary Algorithms, as well as improvement in current techniques.

【最終試験の結果】

令和　５年２月１日、理工情報生命学術院において、学位論文審査委員の全員出席のもと、著者に論文について説明を求め、関連事項につき質疑応答を行った。この結果とシステム情報工学研究群情報理工学位プログラムにおける達成度評価による結果に基づき、学位論文審査委員全員によって、合格と判定された。

【結論】

上記の学位論文審査ならびに最終試験の結果に基づき、著者は博士（工学）の学位を受けるに十分な資格を有するものと認める。