博 士 論 文 審 査 の 結 果 の 要 旨

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論文題目	Dynamic compartmental and performance models for analysis and configuration of multi-objective evolutionary algorithms （多目的進化型アルゴリズムの分析と設定のための動的区画及び性能モデル）
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（博士論文審査の結果の要旨）

Evolutionary algorithms are being used to solve complex optimization problems in science and engineering. However, increasing problem size and complexity demand constant improvement of the algorithms. In addition, given a problem instance, the automatic configuration and selection of an algorithm is an open research field. Algorithm improvements as well as algorithm configuration and selection require a deeper understanding and ways to characterize the behavior and performance of algorithms on a problem instance. This work proposes Dynamic Compartmental Models (DCMs) and a Hypervolume-based Performance Estimation Model to analyze, compare, and configure evolutionary multi-objective algorithms.

Evolutionary algorithms evolve during a number of generations a population of candidate solutions. Inspired by epidemiological models, DCMs track population changes through the generations modeling them as exchanges between compartments. Each compartment contains part of the population. The rules to assign members of the population to a compartment are based on Pareto dominance, recentness of discovery, and membership to the Pareto Optimal Set or the Non-dominated solution set. Given the size for each compartment, the model can estimate their change over time. The behavior of an algorithm with its configuration on a problem instance is represented by one set of parameters.

Small and large instances of the combinatorial MNK-landscape problems solved by representative multi- and many-objective algorithms were used to generate the data to train and test the models. In small instances, the trained models' estimations follow the trend of the data. Using the models' parameters and equations to explain how algorithms can keep discovering good solutions when the population is full, gave an example for algorithm analysis. Finding a correlation between the discovery of optimal solutions and the hypervolume, a performance metric, created a way to use them for comparison between algorithms. For algorithm configuration, an instance was created and solved with several sample configurations of one algorithm. The results produced by the sample configurations were used to create models. Models for additional configurations were obtained interpolating the parameter of the sampled configurations models. The results showed that both trained and interpolated models obtain estimations that can help decide a user which configuration to choose. In larger instances, a different compartment definition around only the non-dominated set was used. For these large instances it is also required the Performance Estimation model

that links these compartments to the growth of the hypervolume to be able to compare and select between algorithms and configurations. The results indicate that these new features defined around the non-dominated set are also able to capture the changes in the population, even on unseen problem instances.

The research results obtained are 1 accepted peer-reviewed journal paper and 5 peer-reviewed international conference papers, have been highly evaluated in the specialized fields of computational intelligence and evolutionary computation, and meet the evaluation criteria of the doctoral course. In addition, all the matters pointed out in the preliminary examination have been appropriately revised and reflected in the thesis.

Taking these factors into consideration, all members of the evaluation committee unanimously judged that this this thesis is worth the doctoral degree.

得られた研究成果は、査読付き学会誌論文 1 件、査読付き国際会議論文 5 件に基づいて構成され、計算知能。進化計算の専門分野において高い評価を受け、講座の審査基準の目安を満たしている。また、予備審査で指摘された事項はすべて適切に修正され、論文に反映されている。

これらを総合的に考慮し、審査委員会全員一致で本論文は学位論文に値すると判断する。

（公表主要論文名）

論文発表（１）（レフェリー制のある学術雑誌）

・Hugo Monzón, Hernán Aguirre, Sébastien Verel, Arnaud Liefooghe, Bilel Derbel, Kiyoshi Tanaka. Estimating Hypervolume using Population Features from Dynamic Compartmental Models. In Transactions of the Japanese Society for Evolutionary Computation. Paper ID: EC-20092801, Date of Acceptance: 23-Dec-2020, Pages 13

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・Hugo Monzón, Hernán Aguirre, Sébastien Verel, Arnaud Liefooghe, Bilel Derbel, Kiyoshi Tanaka. Dynamic Compartmental Models for Large Multi-objective Landscapes and Performance Estimation. In Proceedings of the European Conference on Evolutionary Computation in Combinatorial Optimization (EvoCOP '20), Seville, April, 2020. Pages 15 (99-113). DOI:10.1007/978-3-030-43680-3_7.

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