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博 士 論 文 概 要

論 文 題 目

Study on Population Diversity Preservation for Island Model Genetic Algorithm

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In the Island Model Genetic Algorithm (IMGA), the diversity of the populations is intrinsically preserved. As a result, populations, which are sets of solutions, can be enlarged their ranges and give an advantage in system efficiency. The common problem usually met in IMGA is that the population tends to converge towards local optima. Premature convergence is a term to represent this problem, which occurs too early. The reason behind this is genetic (allelic) drift, which refers to the frequency change of a gene variant (allele) in a population due to a random sampling of organisms. In IMGA, it leads to loss of diversity produced by the usage of finite population sizes.

Premature convergence in IMGA is a consequence of the selection in migration mechanism. It is a process of migrating several individuals (usually the best ones) from a source into destination island to keep its diversity. The main reason is the similar characteristic of the relocated individual because of the genetic operator configurations are similar. Localized Island Model GA (LIMGA) tries to implement different island characteristics (localization strategy) to preserve the islands' diversity.

Another common problem in island model GA is the way to migrate individual from one to another island or usually called a migration policy. Previous researches in this movement protocol could be categorized into two different approaches: diversity preservation-based such as migration protocol in LIMGA and better island pursuing based such as new dynamic migration policy. Therefore, a brand-new migration mechanism called as Dual Dynamic Migration Policy (DDMP) for IMGA is introduced. DDMP will take advantage of the result pursuer of dynamic migration policy and convergence avoider of LIMGA's migration protocol.

Finally, this research aims to preserve global diversity better by exploit LIMGA and DDMP advantages. The combination of LIMGA and DDMP is called as Dual Migration LIMGA (DM-LIMGA). Moreover, DM-LIMGA is also implemented to solve a real-world problem, which is the University Course Timetabling Problem (UCTP).

This dissertation book consists of seven chapters:

Chapter 1 explains the problems and current solutions. This chapter is divided into three subchapters: research background, the scope of previous works, and outline of the thesis. The research background elaborates on the overview, main problems, and purposes that are addressed in this research. The scope of previous works explains the scope of prior research related to this research. The outline of the thesis points to the chapter division of the thesis book.

Chapter 2 discusses the related works of this research. The related works are divided into four main subchapters: genetic algorithm, island model GA, diversity analysis, and migration policy.

GA is the core of this proposed solution. It is a search algorithm inspired by the mechanism of natural selection and genetic mutation. IMGA is a distributed model of GA that splits its primary computational process into several computers (islands) instead of running it in only one machine. This mechanism offers higher scalability and gives a better chance to evade the local optimum trap. Diversity analysis is the main topic of this research. Diversity is the variety of individuals in a population, moreover, an island. This research uses bias value to evaluate the premature convergence tendency of an island. Migration protocol is a mechanism to control individual movement by master island using predefined migration protocol parameter configuration.

Chapter 3 introduces the pre-analysis of LIMGA and its modification to overcome general optimization problems. Furthermore, this chapter also talks about LIMGA performance solving 3SAT benchmarks.

This chapter's goal is the implementation analysis of different island characteristics (localization strategy) to preserve the diversity of the island. This chapter's contribution is mostly to introduce a new mechanism of preserving diversity by analyzing LIMGA in handling general optimization problems. This research uses 15 functions (in 10 and 30 dimensions) from CEC 2015 real-parameter single objective computationally expensive optimization competition as the problem. The experiment shows that LIMGA can get better results in 14 of 30 cases compared to five algorithms, which are also CEC 2015 participants. Furthermore, LIMGA is also proven to solve the Boolean satisfiability problem with three clauses (3SAT). For the 3SAT problem, LIMGA could get better results compared to standard GA and general IMGA in handling SATLIB benchmark problems.

Chapter 4 introduces DDMP for the island model. DDMP splits migrants into two classes, pursuer and avoider depend on the current state of the island. If there is no slave island which has diversity less than the threshold, represented by its bias value, then the migrant will be a pursuer. On another hand, it will take a role as an avoider, which has a task to promote diversity on the island. The experiment result shows that

DDMP could give great results while carrying out CEC 2015 general optimization cases. It could produce the best result for all 15 test functions compare to basic IMGA, IMGA with migration protocol, and IMGA with dynamic migration policy. Furthermore, DDMP still able to keep the ability to preserve its diversity and takes second place after IMGA with migration protocol.

Chapter 5 discusses the combination of DDMP and LIMGA to be DM-LIMGA and its analysis in solving general optimization problems. In summary, LIMGA creates unique evolution trends by using different kinds of GAs for each island, which will delay global convergence. On the other hand, DDMP ensures the individual migrating to the correct island dynamically, which will maintain the overall diversity. So, the combination of LIMGA and DDMP as DM-LIMGA has a great potential to preserve the overall island diversity better than previous IMGA. Our experiments show that DM-LIMGA preserves diversity better. The experiment shows that DM-LIMGA can get the best results in 21 of 30 cases compared to five algorithms, which are also CEC 2015 participants.

Chapter 6 shows the performance of DM-LIMGA to carry out student sectioning University Course Timetabling Problem (UCTP). The UCTP is a scheduling problem of assigning teaching events at a particular time and room by considering the constraints of university stakeholders such as students, lecturers, and departments. And student sectioning UCTP is a problem of assigning students to classes of a subject while respecting individual student requests, along with additional constraints.

We use two kinds of datasets for the experiments: real-world student sectioning Telkom UCTP and International Timetabling Competition 2007 benchmark dataset. Finally, the first experiment using real-world datasets confirms that DM-LIMGA can solve the student sectioning Telkom UCTP with an acceptable result. DM-LIMGA could get the lower violation percentages compared to general GA, Asynchronous IMGA, and UniTime. For the second dataset, this proposed solution could get the lowest violations for 13 of 24 test cases compared to the other 14 algorithms, such as Ant Colony Optimization and Hybrid GA with Tabu Search.

Chapter 7 discusses the conclusion of this dissertation book. This chapter summarizes and tailors the discussion from previous chapters.