Dynamic Selection of Migration Flows in Island Model Differential Evolution

Rodolfo A. Lopes Graduate Program in Electrical Engineering Federal University of Minas Gerais, UFMG Belo Horizonte - MG, Brazil rodolfo.ufop@gmail.com Rodrigo C. Pedrosa Silva Department of Electrical and Computer Engineering Mcgill University Quebec - QC, Canada rodrigo.silva@mail.mcgill.ca

Frederico G. Guimaraes Department of Electrical Engineering Federal University of Minas Gerais, UFMG Belo Horizonte - MG, Brazil fredericoguimaraes@ufmg.br Felipe Campelo Department of Electrical Engineering Federal University of Minas Gerais, UFMG Belo Horizonte - MG, Brazil fcampelo@cpdee.ufmg.br

ABSTRACT

In this paper, a new approach to the topology configuration problem in the Island Model (IM) is proposed. The mechanism proposed works with a pool of candidates for migration and the choice of immigrants is performed using the usual selection techniques of evolutionary algorithms. Computational tests on IM versions of the Differential Evolution show positive effects of the proposed approach in terms of the number of function evaluations required for convergence.

Categories and Subject Descriptors

I.2.6 [Learning]: Parameter Learning; G.1.6 [Numerical Analysis]: Optimization - Stochastic programming, Global optimization

Keywords

Island Model; Migration Topology; Methods of Selection Individual; Differential Evolution

1. INTRODUCTION

The migration process, is the mechanism by which islands in *Island Model(IM)* [4] can exchange high-performance candidate solutions. It has the potential benefit of promoting or advancing the evolution of the subpopulations, introducing new characteristics through the exchange of individuals. In this context, the migration topology which in turn defines the graph of possible inter-island links, plays an important role in the IM.

In this paper, we propose a new configuration mechanism for the IM. This new mechanism attempts to explore the dynamics of the evolution of subpopulations defining the links between the islands through probabilistic methods of selection of individuals (e.g. tournament [5] or roulette wheel

Copyright is held by the author/owner(s).

[2]). To evaluate the proposal comparative tests using different Island Model versions of the Differential Evolution (DE) are presented.

2. DYNAMIC SELECTION OF MIGRATION FLOWS: PROPOSED APPROACH

The proposed approach attempts to explore the dynamics of the evolution of subpopulations considering that the fittest individuals have greater probability of improving the IM. In this new approach an immigrant pool is created with the best individual of each island. Then each island chooses its immigrant using the Roulette Wheel [2] or Tournament [5] selection techniques of evolutionary algorithms. For each island of the IM, the selection method is applied to choose an immigrant among the best individuals from all other islands and this process is repeated until all islands have their own immigrant.

3. EXPERIMENT SETTING

In the experiments, the proposed approaches were compared with the topologies: Ring, Star, Random [7], Kmedoids [1] and Q-learning [3]. IM versions of the Differential Evolution Algorithm (DE) [6] using each one of the approaches were implemented. The parameters were defined in a set of preliminary tests, as: the scale factor of mutation F = 0.7; the crossover probability CR = 0.9; 100 individuals per island; migration every 20 generations and only one individual is replaced by the immigrant per island on any given migration episode. Regarding the Q-learning, the parameters used were $\gamma = 0.5$, $\lambda = 1.0$, $\epsilon = 1.0$ and for the Tournament approach, the selection probability kt = 0.8and tournament size = 3.

Six the functions [8] with 100 variables were used and 15 independent runs in each function were made. The search

GECCO'13 Companion, July 6–10, 2013, Amsterdam, The Netherlands. ACM 978-1-4503-1964-5/13/07.



Figure 1: Comparative Results: 8 Islands



Figure 2: Comparative Results: 16 Islands

was terminated when either of the following conditions were met: The maximum number of generations (20,000) reached and $\Delta f = f_{target} - f_{best} \ll 10^{-4}$. f_{target} and f_{best} represent the know optimal value for the function and the best result found by the algorithm so far, respectively.

4. **RESULTS**

This section presents the comparisons among the proposed approaches. Figures 1, 2 and 3 depicts the empirical cumulative distribution of runtimes (defined here as the number of function evaluations until the optimal solution was reached with a certain precision) of each approach for the IM with 8, 16 and 32 islands. The results were similar regardless of the number of islands. The Ring, Roulette Wheel and Tournament topologies were the highlights between them. The Roulette Wheel was able to achieve good solutions decreasing the number of function evaluations spent. However, the statistical test¹ indicates no significant differences of average.

5. CONCLUSIONS

In this paper, a new approach to the migration configuration problem in Island Model was proposed. In the new approach, the migration flows of the IM are set by a configuration mechanism that works with a pool candidates



Figure 3: Comparative Results: 32 Islands

for migration and the selection of the individuals using the Roulette Wheel or the Tournament methods. The results obtained using IM versions of the Differential Evolution Algorithm suggest a positive effect of the proposed approaches when compared with other topologies. In general, the new approaches are able to achieve good solutions using less function evaluations.

6. ACKNOWLEDGMENTS

The authors would like to thank the following Brazilian agencies for the financial support: CNPq, FAPEMIG and CAPES.

7. **REFERENCES**

- J. Berntsson and M. Tang. Dynamic optimization of migration topology in internet-based distributed genetic algorithms. In *Proceedings of the 2005* conference on Genetic and evolutionary computation, pages 1579–1580, New York, NY, USA, 2005. ACM.
- [2] O. A. Jaddan, L. Rajamani, and C. R. Rao. Improved selection operator for ga. *Journal of Theoretical and Applied Information Technology*, pages 269–277, 2005.
- [3] R. A. Lopes, R. C. P. Silva, F. Campelo, and F. G. Guimarães. A multi-agent approach to the adaptation of migration topology in island model evolutionary algorithms. In *SBRN*, pages 160–165. IEEE, 2012.
- [4] G. Luque and E. Alba. Parallel Genetic Algorithms: Theory and Real World Applications. Studies in Computational Intelligence. Springer, 2011.
- [5] B. L. Miller and D. E. Goldberg. Genetic algorithms, tournament selection, and the effects of noise. *Complex Systems*, 9:193–212, 1995.
- [6] R. Storn and K. Price. Differential evolution a simple and efficient heuristic for global optimization over continuous spaces. pages 341–359, 1997.
- [7] J. Tang, M.-H. Lim, Y.-S. Ong, and M. J. Er. Study of migration topology in island model parallel hybrid-ga for large scale quadratic assignment problems. In *ICARCV*, pages 2286–2291. IEEE, 2004.
- [8] K. Tang, X. Yao, P. N. Suganthan, C. MacNish, Y. P. Chen, C. M. Chen, and Z. Yang. Benchmark functions for the CEC 2008 special session and competition on large scale global optimization. Technical report, Nature Inspired Computation and Applications Laboratory, USTC, China, 2007.

¹Permutation-based analysis of variance (ANOVA) and Permutation tests (coin package of statistical software R) with Benjamini & Hochberg correction.