An Island Based Genetic Algorithm for Dynamic Optimization Problems

H. Homayounfar and S. Areibi and Fang Ju
University of Guelph, School of Engineering
Guelph, Ontario, Canada, N1G 2W1
email:hhomayou@uoguelph.ca, sareibi@uoguelph.ca, fjwang@uoguelph.ca

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Abstract

Many real-world optimization problems are actually dynamic[1]. New jobs are to be added to the schedule, the quality of the raw material may be changing, new orders have to be included into the vehicle routing problem etc. Optimization in dynamically changing environments is a hard problem. If the optimization problem is dynamic, the goal is no longer to find the extrema, but to track their progression through the space as closely as possible. There are two conditions which make an optimization problem dynamic: (i) Information on the problem is time-dependent. The input instance is made known or updated as time goes on. (ii) Solutions must be found while time proceeds, concurrently with incoming informations. This means that no a-priori solutions can be found. The only thing one can do a-priori is determing a 'strategy', or 'policy', which specifies what actions should be taken as a function of the state of the system. In such cases, when the problem changes over the course of the optimization, the purpose of the optimization algorithm changes from finding an optimal solution to being able to continuously track the movement of the optimum through time. Evolutionary Algorithms (EAs) have grown into a mature field of research in optimization, and have proven to be effective and robust problem solvers for a broad range of static real-world optimization problems. Although almost all-real world applications have a dynamic character, evolutionary algorithms (EA, GA) have been developed and examined for statical problems nearly exclusively. While static problems are already hard problems, dynamism adds a new complex degree of difficulty. Yet, evolution strategies are based on the principles of natural evolution, and since natural evolution is a dynamic process in a changing environment, EAs are also well suited to dynamic optimization problems. Since in a sense natural evolution is a process of continuous adaptation, it seems straightforward to consider evolutionary algorithms as appropriate candidates for dynamic optimization problems. The main problem with standard evolutionary algorithms used for dynamic optimization problems appears to be that EAs eventually converge to an optimum and thereby lose their diversity necessary for efficiently exploring the search space and consequently also their ability to adapt to a change in the environment when such a change occurs. We basically use two strategies in this paper to address the problem: (i) Identify the occourence of a change in the environment and then deliberately increase diversity in the population e.g. by means of increased mutation and thus facilitate the shift to the new optimum; (ii) Use multiple populations to cover several promising areas of the search space simultaneously[2]. Island based GAs can enhance the quality of results and at the same time keep the computation time low as larger populations can be processed in less time on parallel or distributed machines. In this model of computation the population is divided into a few subpopulations keeping them relatively isolated from each other. This model of parallelization introduces a migration operator that is used to send individuals from one subpopulation to another. In this paper we investigate the following issues related to island based GA: (1) determining the migration rate and frequency that makes distributed demes behave like a single panmictic population, (2) determining an adequate communications topology that permits the mixing of good solutions, but that does not result in excessive communication costs, (3) finding the optimal number of demes that maximizes reliability.

References

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