Adaptive Meta-Lamarckian Learning in Hybrid Genetic Algorithms

We present strategies for hybrid Genetic Algorithms–Local Searches (GA-LS) control that decide, at runtime, which local method from a pool of different local methods, is chosen to locally improve the next chromosome. The use of multiple local methods during a hybrid GAGS search in the spirit of Lamarckian learning is termed Meta-Lamarckian Learning. Two adaptive strategies are studied on the Griewank test function. The proposed approach is shown to yield robust and improved design search performance.

Adaptive Meta-Lamarckian Learning

Inspired by the research works on different kinds of effort in social evolution, two adaptive strategies of Meta-Lamarckian learning in hybrid GA-LS are structured to promote cooperation and competition among the different local methods, working together to accomplish the shared optimization goal.

Two Cooperation and Competition Adaptive Meta-Lamarckian Strategies

A variety of constrained and unconstrained nonlinear local search methods were employed in the study. Nine hybrid GA-LSs are presented here: GA-BC, GA-CO, GA-DS, GA-HO, GA-FL, GA-LA, GA-NM, GA-PO and GA-PD. These abbreviations have the following meanings:

- GA: Standard GA
- GA-BC: GA with Bit Climbing Algorithm by Davis
- GA-CO: GA with Complex Method of M. Jinn as implemented by Schwefel
- GA-DS: GA with Davies, Swann and Camper Search with Gram-Schmidt orthogonalization as implemented by Schwefel
- GA-HO: GA with Hooke and Jeeves Direct Search by Siddall
- GA-FL: GA with Fletcher’s 1972 method by Siddall
- GA-LA: GA with Repeated Lagrangian Interpolation as implemented by Schwefel
- GA-NM: GA with Simplex Method by Siddall
- GA-PD: GA with Powell’s Direct Search Method as produced by AERE Harwell
- GA-PO: GA with Powell’s Direct Search Method [27] as implemented by Schwefel

Experimental Studies

The basic steps of the hybrid GA-LS search with Meta-Lamarckian Learning are outlined below:

- **BEGIN**
- **Initialize:** Generate an initial GA population.
- **While** (Stopping condition is not satisfied)
  - **For** each individual in the population
    - Select LS using the Meta-Lamarckian Learning Strategy employed and proceed with local improvement.
    - Reward/Update fitness of selected local search method
    - Replace the genotype in the population with the locally improved solution.
  - **End For**
- **Apply** standard GA operators to create a new population; i.e., Selection, Mutation and Crossover.
- **End While**
- **END**

Algorithm for Hybrid GA-LS With Meta-Lamarckian Learning

**Experimental Results On Griewank Benchmark Test Problem**

Griewank function is a multimodal function with many local minima and a global minimum located at (0,...,0). It has a very rugged landscape and is given by:

\[ F_{\text{Griewank}} = \sum_{i=1}^{D} \frac{x_i^2}{4000} - \cos(x_i) + 1 \]

One-dimensional slice of the Griewank function for \([20, 200]^{\text{ij}}\).

Search traces (average of 20 runs) for minimizing 10D Griewank function using the Adaptive Meta-Lamarckian Strategies, i.e., Traces GA-S1 and GA-S2.

The other great advantage of the adaptive Meta-Lamarckian GA-LS strategies is that further improvement of search performance further search may be attained when human designer knowledge is incorporated into the search. Trace GA-S2A illustrates the case where the DS method is biased with twice the chances of being selected, as compared to the other local methods in the same pool. Trace GA-S2B is obtained when the designer chooses to use six local methods (PO, NM, CO, BC, PD and DS) as the pool to perform a search on the Griewank function. It is seen that superior search performances are obtained over the most appropriate local method, GA-DS.

This article may be found at http://www.soton.ac.uk/~cedc/posters.html