Erratum: A Species Conserving Genetic Algorithm for Multimodal Function Optimization

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1 Introduction

In our recent paper "A Species Conserving Genetic Algorithm for Multimodal Function Optimization" (Li et al., 2002), we failed to reference important related work by Goldberg and Wang (1997). This omission was due to our ignorance of this work, and it is unfortunate because there are some similarities between the coevolutionary shared niching (CSN) method of Goldberg and Wang and our own Species Conserving Genetic Algorithm (SCGA).

In the following two sections, we first review the CSN method, as we should have done in our original paper, and then we highlight the similarities and differences between this method and our SCGA.

2 The CSN Method

The CSN method (Goldberg and Wang, 1997) is an adaptive niching scheme designed to overcome the limitations of other sharing schemes when employed within a GA tackling difficult multimodal optimization problems. It draws its inspiration from the model of *monopolistic competition* in economics (Tullock, 1967), and employs two populations: one of customers of size n_c, the other of businesses of size n_b. Both customers and businesses use the same coding and an appropriate measure of distance between a customer c and a business b is defined.

A customer c is said to be *served by* or to *belong to* business b if b is the closest business to c, as determined by the distance measure. The set of customers served by business b at generation t is called the *customer set* of b, denoted by $C_{b,t}$, and the number of customers in this set is denoted by $m_{b,t}$.

The raw fitness $f(c)$ of each customer is given by the standard fitness evaluation. This is then modified in a manner similar to, but importantly different from, standard fitness sharing (Goldberg and Richardson, 1987), such that:

$$f'(c) = \left. \frac{f(c)}{m_{b,t}} \right|_{c \in C_{b,t}} \tag{1}$$

so that an individual shares all the customers served by their business.

The role of the businesses in the CSN method is thus to locate the niches. The fitness of a business $\phi(b)$ is the sum of the raw fitness values of its customers:

$$\phi(b) = \sum_{c \in C_{b,t}} f(c) \tag{2}$$

Using these modified fitnesses the customer and business populations are then evolved in parallel. The customer population is evolved using a simple selectorecombinative GA. In the so-called simple CSN method the business population is evolved using a selectomutational GA. For each individual business in turn, a single mutation is performed. The resulting individual is checked to see whether it is at least a distance d_{min} from the other businesses, and whether it is better (has higher fitness $\phi(b)$) than the original business. If both conditions are met, the new business replaces the original one; if not, the original business is restored and another mutation tried. This procedure is allowed to be repeated up to n_{limit} times. If no new business meeting both conditions is found, the original business is retained.

Goldberg and Wang then improved this business search strategy by introducing a process they called *imprint*, which they implemented as follows: For each business a customer is selected randomly from the current customer population. If this customer (when evaluated as a business) has higher fitness than the original business, and if it is at least a distance d_{min} from the other businesses, then it replaces the original business in the business population. If either condition is not met then another customer is selected randomly. This procedure can be repeated up to n_{limit} times.

3 Similarities and Differences Between CSN and SCGA

3.1 Motivation

Both CSN and SCGA are methods designed to improve GA search in difficult multimodal optimization problems. CSN takes its inspiration from the field of *economics*, while SCGA takes its inspiration from the field of *ecology*.

3.2 Role of the Secondary Population

Both methods employ a secondary population of solutions. The intention in both cases is to ensure the selection of solutions that are different and highly fit, but the way in which this is achieved is different.

In CSN, the secondary population (the business population) evolves in parallel with the primary population (the customer population). The role of the business population is to locate the niches that are then exploited in the evolution of the customer population through a novel form of fitness sharing. Through the imprint process the business population is improved by importing higher performing individuals from the customer population. In the form implemented and tested by Goldberg and Wang (1997), imprint is a stochastic process. Thus, in CSN, the secondary population is used to improve *niching* performance, and thereby algorithm performance.

In SCGA, the secondary population (the set of species seeds) is drawn deterministically from the current population. The role of the set of the species seeds is to facilitate conservation of solutions primarily on the basis of their mutual dissimilarity. Each species seed is then selected, again deterministically, to enable that species to continue to breed in the next generation, unless a higher performing member of the same species has evolved. Thus, in SCGA the secondary population is used to implement *distributed elitism*, and thereby to improve algorithm performance.

3.3 Control Parameters

In implementing CSN, three control parameters, in addition to those needed by any GA, must be defined: the minimum distance d_{min}, the number of businesses n_b and the trial repetition limit n_{limit}.

In implementing the SCGA, just one additional control parameter must be defined: the *species distance* σ_s. The SCGA seeks solutions that are significantly different, with the species distance defining what "significantly different" means (d_{min} serves the same purpose in CSN, of course). This definition can be domain or problem specific.

4 Conclusions

CSN and SCGA both seek to improve GA search in difficult multimodal optimization problems. Although superficially their use of secondary populations makes them appear similar, their fundamental strategies for improving GA search are different: CSN does so through exploiting more effective niching; SCGA through exploiting distributed elitism.

Now that we have become aware of the attractions of the CSN method, it will be interesting to compare its performance with that of the SCGA method, and this will be investigated as soon as possible.

Acknowledgments

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