

Simplex Crossover and Linkage Learning in Real-Coded GAs

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Abstract: In this paper, we propose a method of linkage identification in real-coded GAs with *simplex crossover* (SPX) and evaluate it using several test functions.

1. Introduction

Previous studies [Tsutsui 99], [Higuchi 00] have proposed *simplex crossover* (SPX) for real-coded GAs. SPX works well on various test functions. However, SPX fails on functions that consist of multiple tightly linked sub-functions. On those functions, SPX should be applied on each tightly linked parameters group, i.e., each simplex should be formed in each subspace in which parameters are tightly linked. Thus, we need a method of identifying those tightly linked parameter groups.

In this paper, we propose a method of linkage identification for real-coded GAs with SPX and evaluate it using several test functions.

2. SPX [Tsutsui 99], [Higuchi 00].

The SPX operator uses $n+1$ parental vectors $X_i, i = 0, 1, \dots, n$ for recombination. These $(n+1)$ vectors form a *simplex* in R^n . Then this simplex is expanded in each direction $(X_i - O)$ to some extent, where O is the center of mass of $(n+1)$ parental vectors. Offspring are then generated by *uniformly* picking vector values from this expanded simplex.

3. Linkage identification with piecewise interval correlation by iteration

In this study, we consider evaluation functions that can be written as

$$F(X) = F_{\text{tight},1}(X_{\text{tight},1}) + \dots + F_{\text{tight},S}(X_{\text{tight},S})$$

Here, each sub-function $F_{\text{tight},s}(X_{\text{tight},s}) (s=1, \dots, S)$ has tight linkage among parameters. For these kinds of functions, we intuitively notice that we it is better to apply SPX in each subspace $X_{\text{tight},s} (s=1, \dots, S)$ separately. Then the problem is how to identify each tight linkage group.

The linkage information among parameters can be obtained by observing the distribution of individuals in a population. If $F(X)$ has a linkage between parameters on loci x_p, x_q , then there should be some degree of correlation between $x_i - x_p, x_j - x_q$, and $x_k - x_i$. Thus if we examine the correlation coefficient matrix $R = [\rho_{ij}]$ of parameter values of individuals in a population, linkage among parameters might be detected. However, this normal correlation coefficient can examine only linear correlations among parameters. We must use some non-linear estimation technique such as non-linear

regression or higher moment methods. This paper propose a *piecewise interval correlation by iteration* (PICI) algorithm, a more simple and straightforward extension of the linear correlation. It calculates correlation coefficients of piecewise intervals (Fig. 1).

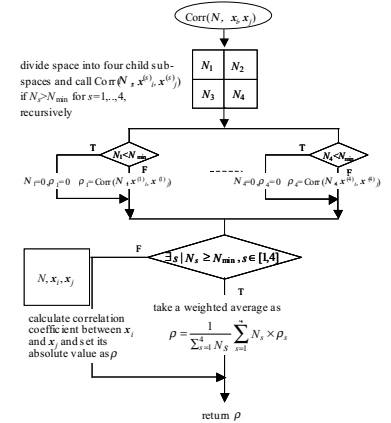


Fig. 1 PICI algorithm

4. Experiments

To evaluate the linkage identification method proposed in Section 3, we run a real-coded GA. Here we show only a typical results on the following function (see Table 1):

$$F_{R2-n}(X) = F_{R2}(x_1, x_2) + F_{R2}(x_3, x_4) + \dots + F_{R2}(x_{n-1}, x_n)$$

where $F_{R2}(x_1, x_2)$ is the Rosenbrock function. We can see the effect of the proposed approach.

Table 1 Results on $F2-n(X)$

n	without linkage learning		with linkage learning	
	#OPT	MNE	#OPT	MNE
4	20	67.721.8	20	54.830.8
8	20	191.046.8	20	135.136.1
12	18	697.515.4	20	225.800.8
16	0	-	20	295.944.5
20	0	-	20	354.135.5
24	0	-	20	402.790.9
28	0	-	20	448.570.9
32	0	-	20	497.641.3
36	0	-	20	540.894.5
40	0	-	20	584.640.5

5. Conclusions

In this paper, we have proposed a method for linkage identification in real-coded GAs with SPX. Without linkage identification, it was difficult for the algorithm with SPX to find the optimal solution on these test functions. With the proposed linkage identification method, the algorithm found optimum solutions fairly well on the test functions. This work was partially supported by AFOSR grant No. F49620-00-0163 and NSF grant DMI-9908252.

References

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