Using incremental evaluation and adaptive choice of operators in a genetic algorithm

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Abstract

The number of fitness evaluations determines the efficiency of a GA. This research suggests incremental evaluation which, if applicable, substantially reduces the complexity of evaluation of some individuals. Incremental evaluation and rational choice of operator based on utility maximization gives a two-fold reduction in computational cost needed to optimize the one-max function.

In this work, the problem "crossover vs mutation" is formulated as a decision problem using multiattribute utility theory (MAUT) (Keeney & Raiffa, 1993). The multilinear utility function of operators is based on ideas of Goldberg (1998). After assessing the utility function, MAUT is used to find a rational trade-off between crossover and mutation. The one-max function is the simplest function that can be evaluated incrementally and interesting results with it can motivate further research of more complex fitness functions.

Here we skip a detailed utility function assessment, and present only the final result:

$$U(F, I, S) = 0.06U(I) + 0.04U(S) +$$
$$+0.6U(F)U(I) + 0.3U(F)U(S)$$

where F is the number of applications per fixed cost, I is innovation rate, S is a scrap rate. According to this formula, utilities of crossover and mutation are $U_c \approx 0.09$ and $U_m \approx 0.36$. Apparently $U_c < U_m$, so the optimal strategy according to decision theory seems to always use mutation. However the experiments with only mutation produced inferior results. That is because utilities of operators change significantly during the run. However it is easy to recalculate the utilities in each generation. This gives us an adaptive algorithm that always selects an operator with maximumal estimated utility.

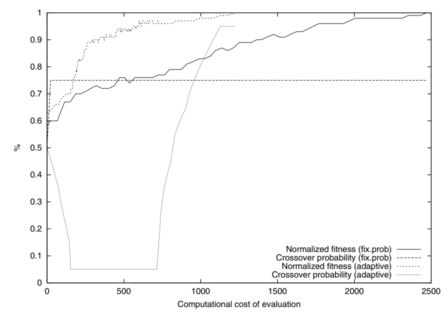

Figure 1: Comparison of adaptive sampling vs sampling with fixed probabilities

The utility of application of mutation operator is higher initially, however later the situation changes. It makes the adaptive algorithm change its preferred innovation operator (figure 1). Here we compare the average results: for fixed crossover probability $p_x = 0.75$ the average computational cost is 2568.30; for the adaptive algorithm, it is 1334.18.

This research proposes the rational choice of crossover and mutation. Genetic algorithm that chooses an operator with maximum utility has shown two-fold reduction in computational costs.

References

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