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THE MODIFIED GENETIC ALGORITHM WITH AUTOMATIC ADJUSTMENT

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The genetic algorithms in various forms are widely used for solving of many technical and scientific problems. One of the most important applications of the genetic algorithms is optimization of functions. The genetic algorithms have important features thanks to which they demonstrate advantages over traditional methods of optimization: the genetic algorithms operate with a population of solutions, the genetic algorithms use only values of criterion function and do not use any additional information, the genetic algorithms are stochastic optimization procedures. But the genetic algorithms have essential drawback: they demand accurate adjustment of parameters for each problem in hand in order to obtain an optimum solution for acceptable time. If the user chooses options at arbitrarily, then he can receive both a high efficiency and very low one. At the decision of the majority of problems, especially real world problems of optimization, this approach is unacceptable, because we need to get the best possible solution for limited time.

In this paper the way of the partial solution of a problem is suggested. It consists of reduction of quantity of adjusted parameters. The author has developed and tested 7 genetic algorithm modifications: the genetic algorithms with automatic adjustment of selection type, crossover type, mutation level, and also combinations such as selection + mutation, selection + crossover, mutation + crossover, selection + mutation + crossover.

The way of all algorithms operate in is the following. On each generation, the estimation of probabilities distribution for settings or their combinations choice, that participate in formation of individuals next generation, is fulfilled. These probabilities depend on individuals quality based on fitness function value obtained using of these settings. Initially all probabilities are equal to each other, because the algorithm still does not have information about successful and unsuccessful settings. Any probability never becomes equal to 0, because all settings are necessary when solving sophisticated tasks.

For estimation of convergence speed of the algorithm to a known optimum solution 2 approaches were used such as average quantity of fitness function evaluations (before extremum finding for the first time) and average number of generation (when the algorithm finds for the first time the extremum). These approaches are equivalent when solving problems of unconstrained optimization, because all algorithms operate with the identical size of population, i.e. carry out identical quantity of fitness function evaluations. The operating time of all algorithms was measured from the beginning and before the work termination instead of to the first finding of an extremum in order to objective comparison of an operating time of the suggested algorithms.

The suggested algorithms were compared with standard genetic algorithm in order to check correctness and efficiency of functioning. Efficiency and correctness of suggested genetic algorithms and standard algorithm is compared with testing tasks of unconstrained optimization. A testing technique is usual, test functions are standard. The total number of combinations of settings for one optimization problem is equal to 360 (5 selection types, 3 crossover types, 3 mutation levels, 2 ways of control of population, the concept of elitism and its absence, 2 ways of representation of individuals) for standard algorithm. The total number of combinations of settings five times is less, than for standard algorithm, and is equal to 72 for algorithm with automatic adjustment of selection. The total number of combinations of settings in 3 times is less, than for standard algorithm, and is equal to 120 for algorithm with au-

tomatic adjustment of mutation. The total number of combinations of settings in 3 times is less, than for standard algorithm, and is equal to 120 for algorithm with automatic adjustment of crossover. The total number of combinations of settings in 15 times is less, than for standard algorithm, and is equal to 24 for algorithms with automatic adjustment of selection + mutation and selection + crossover. The total number of combinations of settings in 9 times is less, than for standard algorithm, and is equal to 40 for algorithm with automatic adjustment of mutation + crossover. The genetic algorithm with automatic adjustment of selection + mutation + crossover has only 8 combinations of settings, that it is less in 45 times, than for standard algorithm.

In table 1 average results of testing standard and the modified algorithms with 10 test functions (number of independent starts – 500, binary string on 46-50 bits, resources – 100 individuals on 100 generations) are represented. Averaging was made on set of test problems. According to the received average results, the spread of an operating time of algorithms at various combinations of settings, the spread of average number of generations (when the algorithm finds for the first time an extremum), the spread of average quantity of fitness function evaluations (before extremum finding for the first time) were defined. The settings, when reliability is equal to zero, were not considered.

Table 1

Average results of testing of genetic algorithms

Type of genetic algorithm	Spread of reliabilities	Spread of an operating time (s.)	Spread of average generations (when the algorithm finds for the first time the extremum)	Spread of average quantity of calculations of criterion function (before extremum finding for the first time)
The standard	[0, 1]	[22, 74]	[21, 84]	[2252, 8512]
Selection automatic adjustment	[0.71, 1]	[34, 68]	[26, 59]	[2707, 6013]
Mutation automatic adjustment	[0, 0.99]	[20, 63]	[21, 84]	[2259, 8516]
Crossover automatic adjustment	[0, 1]	[29, 76]	[22, 85]	[2319, 8545]
Selection and mutation automatic adjustment	[0.88, 0.99]	[33, 66]	[28, 39]	[2907, 3949]
Selection and crossover automatic adjustment	[0.25, 1]	[36, 61]	[28, 66]	[2861, 6732]

Table 1 continuation

Type of genetic algorithm	Spread of reliabilities	Spread of an operating time (s.)	Spread of average generations (when the algorithm finds for the first time the extremum)	Spread of average quantity of calculations of criterion function (before extremum finding for the first time)
Mutation and crossover automatic adjustment	[0, 0.99]	[27, 70]	[23, 81]	[2444, 8199]
Automatic adjustment of selection, mutation and crossover	[0.93, 1]	[39, 60]	[28, 35]	[2903, 3581]

According to the results of this testing, it is possible to make following conclusions:

- Statistical stability was observed when testing of algorithms.
- All suggested algorithms demonstrate an operating time, comparable with standard genetic algorithm.

- Standard genetic algorithm and algorithms with an automatic adjustment of a mutation, crossover and combination of mutation + crossover are provides the greatest spread of reliabilities. The main reason consists in following. All selections participate in formation of individuals including the worst for this specific task, i.e. this selection provides very low reliability of functioning. What's more, these modifications provide wide spread of numbers of average generations (when the algorithm finds for the first time an optimum solution), compared with the standard algorithm.
- The modified genetic algorithm with simultaneous adjustment of three parameters such as selection, mutation and crossover provides the least spread of reliabilities of functioning, the least spread of an operating time, the least spread of average quantity of fitness function evaluations (before extremum finding for the first time) or average number of generations (when the algorithm finds for the first time the extremum).

According to the results of this paper, the modified algorithm with simultaneous automatic adjustment of selection, mutation and crossover can be recommended as replacement for standard algorithm. This algorithm reduces number of combinations of settings in 45 times and provides high reliability (more than 0.9) at arbitrarily choice of other settings, compared with the standard algorithm. This algorithm provides the minimum spread of average quantity of fitness function evaluations before extremum finding for the first time. This algorithm provides an operating time, comparable with standard genetic algorithm.