I-514 Basic Research On GA With The Growth Operator

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1. Introduction

A simple genetic algorithm(GA) includes generally three genetic operators, reproduction(selection), crossover and mutation[1]. It was applied to discrete optimization problems in the early stage of our study. Indeed, it provided good optima for some problems with a few variables and small design space. But it was not efficient to even 5 design variables problem. This indicated that the random mating, crossover and mutation in a finite population could not guide the optimal research to a true optimum[2)3)]. The improvement presented so far in published papers has been concentrated on the crossover and mating. However, in this paper, a modified method, or in other words, a new genetic operator named ''Growth'' temporarily, is proposed while random mating and random crossover are still maintained. It is used in GA like other three operators. Numerical examples presented here show that the GA with such a growth operator is superior and is able to solve the larger problems.

2. Growth Operator

The explanation of simple GA can be found in Goldberg(1989). The basic concept of the growth operator is explained here.

A big problem still to be solved in application of GA is the following: How should a finite population with random mating and crossover lead to an efficient progress through preventing evolution from convergent to suboptimal solutions, or in other words, how can a small population search a huge space in an efficient way. The growth operator circumvents the above problem by such a substrategy: Each string in population is improved by the growth operator and increases its fitness value before going to crossover with other string. In this way, although random mating and crossover are still used, the strings grown up through the growth operator can create the better offsprings than simple GA where random mating and crossover often forms the worse offsprings due to the very low fitness of one partner. This also prevents the population fitness from reducing to fitness minima.

So far there is few literature discussing about mutation in detail. The simple mutation has been widely used in many literatures. Our growth operator is proposed as a new genetic operator, but on the other hand, it may be regarded as the directed mutation which differs from the one in simple GA completely where it plays a secondary role and is a random walk through the string space with a very low probability. The random mutation is essential in natural evolution but no means in a simulation finite population where a fast evolution is necessary. Therefore applying the directed mutation, or growth operator can guide the optimal research to look into the area where it seems worthwhile and improve the efficiency of GA.

The growth operator can be used in different forms according to different problems. At the same time, it may contain some branches which perform different functions separately.

3. Numerical example

The specific use of the growth operator in discrete optimization of truss structures with ready-made steel can be described as follows: It is composed of three branches. Let each string in a given generation grow up by employing any one among the following three procedures at random.

1) The ranks of those members which not satisfy constrains are increased until satisfying.
2) The ranks of those members having still enough strength is reduced to the minimum ranks which exactly satisfy the constrains.
3) The ranks of all members are not changed at all.

Increasing and decreasing the ranks of members also means that some bits in a string are mutated directly based on increasing the values of fitness of that string.

Fig.1 shows the 22-members truss. The number of design variables is 12. If design carries out within 16 section sizes of ready-made steel, the order of combinations will reach more than two thousand million(16^{12}). Table 1 gives the results in two methods, simple GA, modified GA adding the growth operator. The design variables are represented by the ranks of steels. The number in the bracket means the generation in which the best result arises. As shown in the table, modified GA gives the optima in more than half cases[4].

Fig.2 shows the convergence trend of average objective over the generations of evolution and the best result of each generation. The population size is 60. Undoubtedly, modified GA presents the faster convergence.

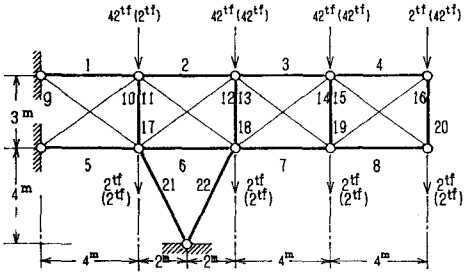

Fig.1. 22-members truss

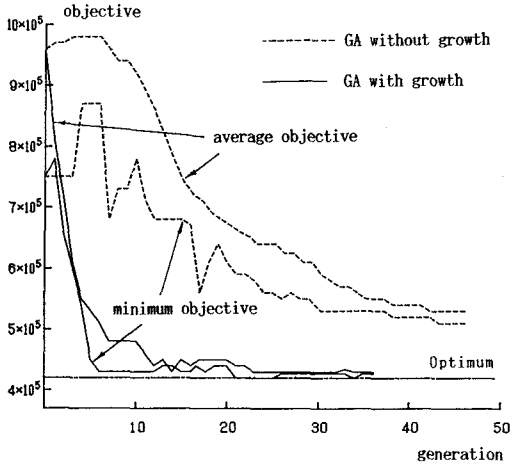

Fig.2. History of 22-members Truss

Table 1. Results of 22-members Truss

Population Size	GA without Growth Operator													GA With Growth Operator											
	Design Variables												Obejective	Design Variables											Obejective
10	12	9	3	13	6	6	4	7	9	10	4	15	866550 (11)	4	7	2	5	1	2	3	7	1	4	1	10	441982 (36)
20	4	9	3	13	2	2	3	12	7	5	7	14	676740 (29)	4	8	3	4	1	1	3	7	1	4	2	10	434910 (29)
40	3	7	5	7	1	3	2	6	8	8	1	11	547306 (38)	4	8	2	4	1	1	3	7	1	4	1	10	424942 (27)
60	3	7	5	8	2	3	2	6	3	9	1	14	519810 (43)	4	8	2	4	1	1	3	7	1	4	1	10	424942 (21)
80	3	7	3	5	1	3	2	9	3	9	1	11	485310 (50)	4	7	2	5	1	1	3	7	2	4	1	10	434040 (15)
100	3	8	1	5	1	3	3	6	2	6	1	11	454880 (49)	4	8	2	4	1	1	3	7	1	4	1	10	424942 (16)
120	4	7	1	6	2	2	3	7	2	6	3	11	462600 (48)	4	8	2	4	1	1	3	7	1	4	1	10	424942 (41)
Optimum	4	8	2	4	1	1	3	7	1	4	1	10	(424942)												

4. Conclusion

GA is efficient to those optimization problems which can not be solved effectively in usual method based on the gradients of the continuous function. GA with the new operator, growth, is proved works well to middle-scale discrete optimization problem in this paper. The efficiency of GA is improved by using this growth operator. The use of this method in framed-structures is under study.

References

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