An Adaptive Method of Hungarian Mating Schemes in Genetic Algorithms

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ABSTRACT

Mating scheme is one of the key operations in genetic algorithms. In this paper, we propose an adaptive mating method combining Hungarian mating schemes that have been previously suggested. Hungarian mating schemes include i) minimizing the sum of matching distances, ii) maximizing the sum, and iii) random matching. Our adaptive mating method selects one of the schemes with voting. Every matched pair of individuals has the right to vote for the mating scheme of the next generation. Its preference is closely related to the ratio of distance between parents over distance between parent and offspring. We apply the proposed method to well-known combinatorial optimization problems, the traveling salesman problem and the graph bisection problem. The proposed adaptive method showed better performance than any single Hungarian mating scheme and the non-adaptive hybrid scheme presented in previous work.

Categories and Subject Descriptors

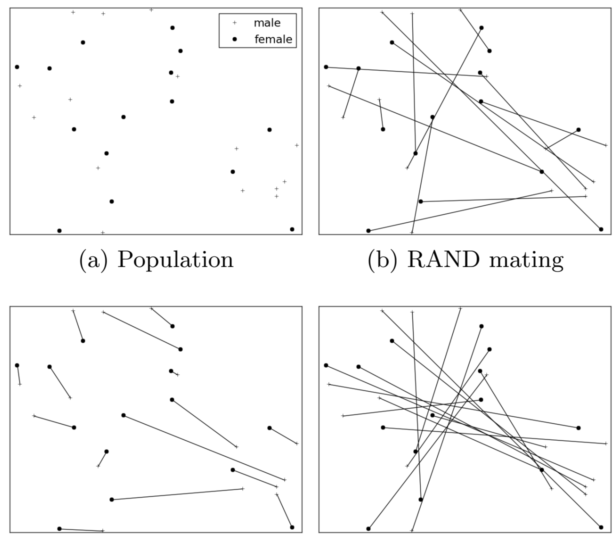
I.2.8 [**Problem Solving, Control Methods, and Search**]: Heuristic methods

Keywords

Mating scheme, genetic algorithm

1. INTRODUCTION

Selection or mating scheme is one of the key operations in genetic algorithm (GA). In this paper, we suggest an adaptive hybrid Hungarian mating scheme with voting. We test out the scheme on well-known combinatorial optimization problems: the traveling salesman problem (TSP) and the graph bisection problem. We summarize the contribution of this paper as follows: i) We suggest a new adaptive hybrid mating scheme, ii) we explain why it works, and iii) we show that our scheme is more effective than a previous simple hybrid scheme and any single Hungarian scheme for the above two problems.



(a) Population (b) RAND mating

(c) NEAR mating (d) FAR mating

Figure 1: Hungarian mating schemes [1]

2. HUNGARIAN MATING SCHEME

Recently, we suggested Hungarian mating schemes [1]. They applied the Hungarian method for mating solutions, using a proper distance metric defined for each problem.

Figure 1(b) represents random mating. The scheme is called “RAND”. Figure 1(c) shows the result yielded by minimizing the sum of distances with the Hungarian method. Figure 1(d) shows the result yielded by maximizing the sum with Hungarian method.

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Algorithm 1 Voting rules

```
// input: two parents and two offspring
// output: FAR, NEAR, or RAND
// d(x, y): distance function between x and y
Function vote(p1, p2, o1, o2)
{
  if d(p1, p2) = 0, d(p1, o1) = 0, or d(o2, p2) = 0 then
    return FAR;
  end if
  ratio ← d(p1, p2) / (d(p1, o1) + d(o2, p2));
  if ratio < α then
    return FAR;
  end if
  if α ≤ ratio < β then
    return RAND;
  end if
  if ratio ≥ β then
    return NEAR;
  end if
}
```

3. PROPOSED METHOD

Our goal is to design a new adaptive hybrid method of the Hungarian mating schemes. We want that: i) our new scheme works in various instances or problems, ii) it is adaptive, and iii) it outperforms any single Hungarian mating scheme. We will propose a new scheme satisfying these characteristics.

Algorithm 1 describes the rules of voting. If one of the offspring is the same as one of the parents, this family votes to FAR. Otherwise, a ratio of distance between parents over the sum of the father-son distance and the mother-daughter distance is considered. If the ratio value is below α, this family votes to FAR. If the ratio is not less than α and below β, this family votes to RAND. The last case, in which the ratio is not less than β, this family votes to NEAR. After voting, the strategy which gets the most votes is set for the next generation. We set α and β as 0.5 and 1, respectively with some theoretical observation. With a geometric crossover [2], the expected value of the ratio is 1 and the lower bound of the ratio is 0.5.

4. EXPERIMENTS

4.1 Traveling Salesman Problem

We selected four Euclidean instances from TSPLib. Each number in the instance name means the number of cities in the instance.

Table 1 shows the statistical significance. 'single best' denotes the best single Hungarian mating scheme among three schemes (FAR, RAND, and NEAR). 'simple hybrid' is the strategy introduced in our previous work [1]. A plus mark (+) means that it has passed t-test under significance level 0.01. Our method are significantly superior to the others.

4.2 Graph Bisection Problem

We tested on four popular instances with 1,000 vertices. The number of the right part of each name means the average vertex degree. Table 2 shows t-test results with the same way as used in TSP. Our scheme significantly outperformed the others except one instance.

Table 1: Statistical Test of TSP

Instance	Compared method	t-test	t-value	p-value
berlin52	single best	+	3.01	1.33e-03
	simple hybrid	+	5.75	5.71e-09
kroA100	single best	+	24.38	1.0e-103
	simple hybrid	+	14.00	4.01e-42
bier127	single best	+	14.24	2.41e-42
	simple hybrid	+	8.65	9.72e-18
pr152	single best	+	10.79	4.46e-26
	simple hybrid	+	6.31	2.01e-10

t-value: the bigger, the larger difference.
p-value: the smaller, the more significant.
+: significantly better under level 0.01.

Table 2: Statistical Test of Graph Bisection

Instance	Compared method	t-test	t-value	p-value
G1000.2.5	single best	+	6.15	5.66e-10
	simple hybrid	+	2.82	2.44e-03
G1000.20	single best	+	5.48	2.69e-08
	simple hybrid	+	2.55	5.30e-03
U1000.05	single best	+	8.25	2.42e-16
	simple hybrid	+	5.18	1.32e-07
U1000.40	single best	∼	1.54	6.23e-02
	simple hybrid	+	3.47	2.62e-04

∼: not significantly different under level 0.01.

5. CONCLUSION

We analyzed the effect of the proposed mating scheme in two combinatorial optimization problems: TSP and graph bisection. Our mating scheme assesses the matched distance of individuals with their offspring. The NEAR scheme focuses on exploitation while FAR scheme focuses on exploitation. Our scheme tries to find a balanced point between exploration and exploitation in each generation.

Real-coded problems may have different characteristics from combinatorial optimization. More various problems such as function optimization can be tested with our scheme. There is room for further improvement and we will study the presented scheme with various operations such as crossover, mutation rates, replacement, and local-optimization for future work.

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