# Study Diploid System by a Hamiltonian Cycle Problem Algorithm

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**Abstract.** Complex representation in Genetic Algorithms and pattern in real problems limits the effect of crossover to construct better pattern from sporadic building blocks. Instead of introducing more sophisticated operator, a diploid system was designed to divide the task into two steps: in meiosis phase, crossover was used to break two haploid of same individual into small units and remix them thoroughly. Then better phenotype was rebuilt from diploid of zygote in development phase. We introduced a new representation for Hamiltonian Cycle Problem and implemented an algorithm to test the system.

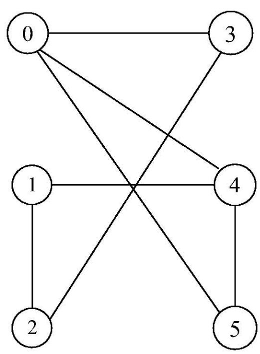
Our algorithm is different from conventional GA in several ways:

- The edges of potential solution are directly represented without coding.
- Crossover is only part of meiosis, working between diploid of same individual.
- Instead of mutation, the population size guarantees the diversity of genes.

Since Hamiltonian Cycle Problem is a NP-Complete problem, we can design a search algorithm for Non-deterministic Turing Machine.

**Table 1.** A graph with a Hamiltonian Cycle of (0, 3, 2, 1, 4, 5, 0), and two representation of Hamiltonian cycle

| Edges In Order Of Connection | |
|---|---|
| Start | End |
| 0 | 3 |
| 3 | 2 |
| 2 | 1 |
| 1 | 4 |
| 4 | 5 |
| 5 | 0 |




| Edges In Order Of First Vertex | |
|---|---|
| Start | End |
| 0 | 3 |
| 1 | 4 |
| 2 | 1 |
| 3 | 2 |
| 4 | 5 |
| 5 | 0 |

To find the Hamiltonian Cycle, our Non-deterministic Turing Machine will:

E. Cantú-Paz et al. (Eds.): GECCO 2003, LNCS 2723, pp. 152–153, 2003.

- Check the first row. Choose a vertex from vertices connected to current first row vertex. These two vertices designate an edge.
- Process other rows in the same way. If there is a Hamiltonian Cycle and every choice is right, these n edges construct a valid cycle.

Therefore, we designed an evolutionary algorithm to simulate it approximately:

- Every individual represents a group of *n* edges got by a selecting procedure made by random or genetic operators.
- The fitness of an individual is the maximal length of contiguous path can extend from start in the edge group.

| START | END |
|---|---|
| 0 | 3 |
| 1 | 4 |
| 2 | 1 |
| 3 | 2 |
| 4 | 0 |
| 5 | 4 |

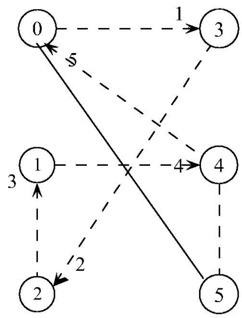



**Fig. 1.** Expression of genotype. Dashed edges are edges in genotype. Numbers in edges note the order of expression. The path terminated in 4-0 because of repetition

Since Hamiltonian Cycle Problem highly depend on the internal relation among vertices, it will be very hard for crossover to keep the validity of path and pattern formed at the same time. If edges are represented in path order, crossover may produce edge group with duplicate vertices; if edges are represented in the same fixed order, the low-order building blocks cannot be kept after crossover. Fortunately, the meiosis and diploid system in biology provide a solution for this problem. It can be divided into two steps:

1. Meiosis. Every chromosome got in gamete can come from either haploidy. Crossover and linkage occurred between corresponding chromosomes.
2. Diploid expression. No matter how thoroughly recombination had been conduct in meiosis, broken patterns can be recovered, and a better phenotype can be obtained with two options in every alleles. Our algorithm tests all the possible options in new searching branch and keeps the maximal contiguous path. The search space is not too much because many branches will be pruned for repeated vertex. Of course, we limited the size of searching branches pool.

It was proved that the algorithm usually solves graph with 16 vertices immediately. For larger scale (1000 ~ 5000) it had steady search capability only restrained by computing resource (mainly in space, not in time). Java codes and data are available from http://ai.ia.ac.cn/english/people/draco/index.htm.

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