Order-Based GA

L. Davis, Handbook of GA, Chap. 6

Introduction

Encoding technique for a combinatorial optimization problem

Improve the performance with GA + Greedy algorithm

The graph coloring problem

Graph

The graph coloring problem

The Greedy node coloring algorithm

Greedy Algorithm

An optimization algorithm that proceeds through a series of alternatives by making the best decision, as computed locally, at each point of the series

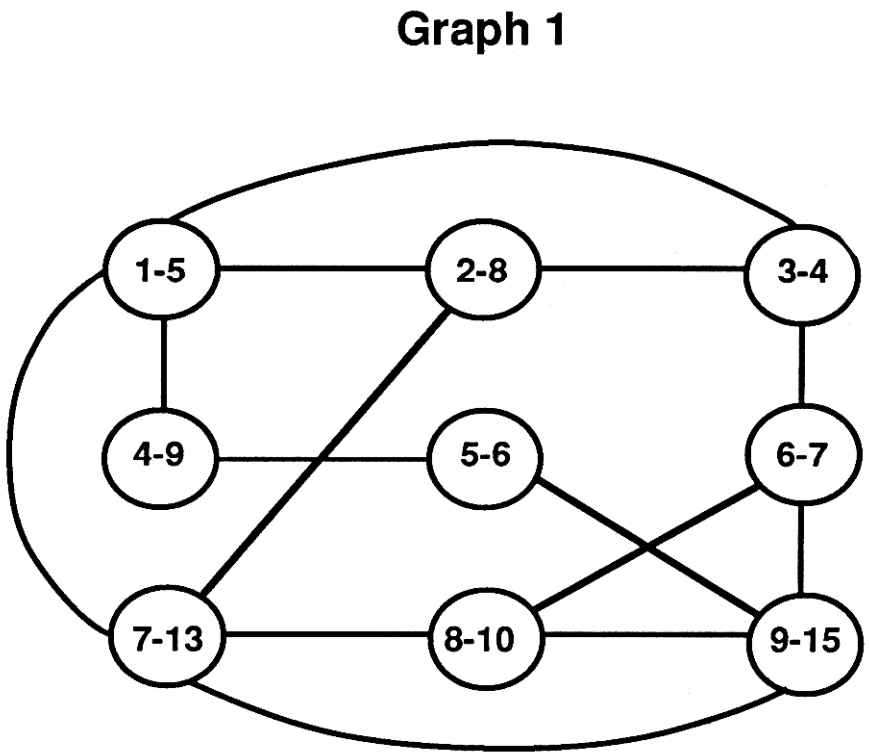

Figure 6.1: Example graph 1. Circles indicate nodes and lines indicate links. Inside each circle is the node's index and weight.

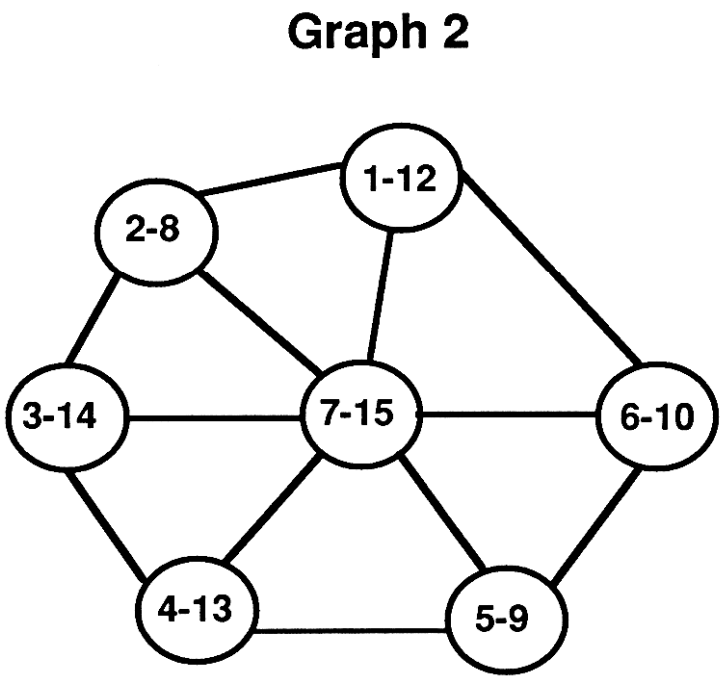

Figure 6.4: Example graph 2, a "hub and spokes" graph.

The graph coloring problem

Number of colors

- One coloring
- Two coloring

NP-complete: No strategy for solving a problem is guaranteed to succeed quickly and optimally for all possible problem instances

Order-based representation

A technique for encoding solutions

- Order the nodes on the graph in some way (weights, degrees), and then decode the ordering just as the greedy algorithm did

Node coloring evaluator

- The evaluation function takes each of the nodes on a chromosome in order and assigns each the first legal color that node can have, if any

Order-based representation

Permuted list representation

- Every chromosome used by the genetic algorithm is the permutation of the list of nodes on the graph

Initialization with random permutation

- Generate random permutation of the list of nodes
- Incorporate the chromosome generated by the greedy algorithm

Reordering Operators

PMX (Partially Matched Crossover)

A = 9 8 4 | 5 6 7 | 1 3 2 10

B = 8 7 1 | 2 3 10| 9 5 4 6

It uses position-wise exchange

A'= 9 8 4 | 2 3 10 | 1 6 5 7

B'= 8 10 1 | 5 6 7 | 9 2 4 3

Application to blind traveling salesman problem (see Figure 5.17, 5.18)

PMX respects absolute city position

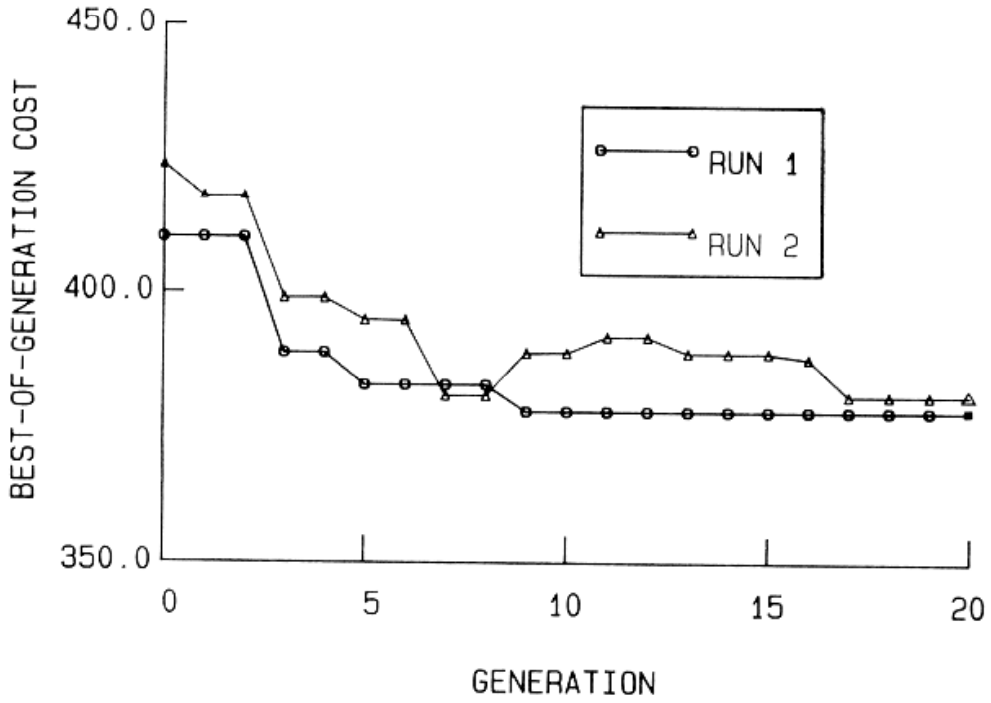

FIGURE 5.17 Partially matched crossover (PMX) operator in 10-city blind traveling salesman problem. Run 1 converges to optimal results. Population size $n = 200$ with $p_c = 0.6$. From Goldberg and Lingle (1985).

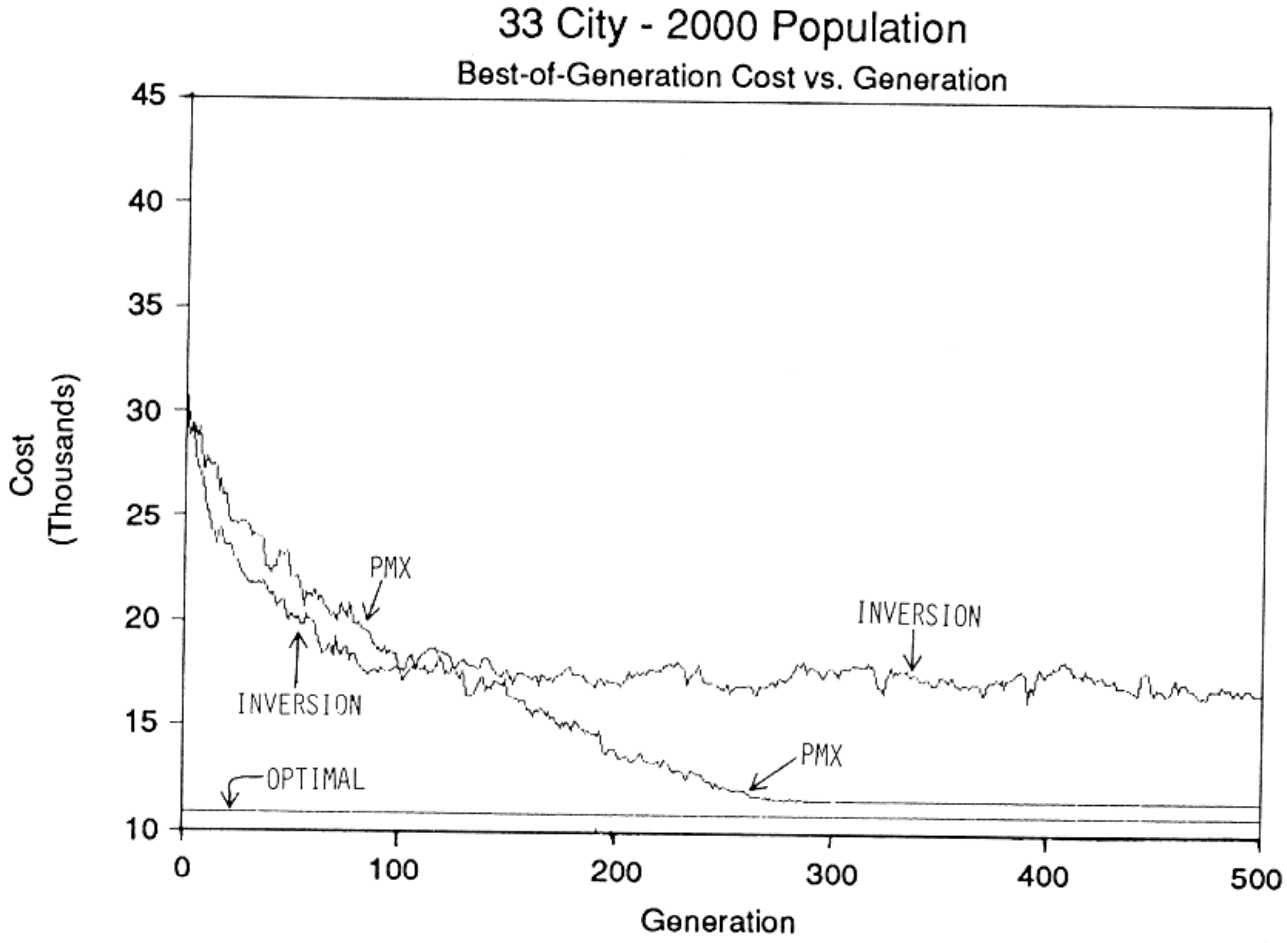

FIGURE 5.18 **Partially matched crossover (PMX) operator in 33-city blind traveling salesman problem.**

Reordering Operators

OX (Order Crossover)

A = 9 8 4 | 5 6 7 | 1 3 2 10

B = 8 7 1 | 2 3 10 | 9 5 4 6

It uses a sliding motion that starts following the second crossing site to fill the holes left by transferring the mapped positions

B = 8 h 1 | 2 3 10 | 9 h 4 h

B = 2 3 10 | h h h | 9 4 8 1

A'= 5 6 7 | 2 3 10 | 1 9 8 4

B'= 2 3 10 | 5 6 7 | 9 4 8 1

OX tends to respect relative city position

Reordering Operators

CX (Cycle Crossover)

C = 9 8 2 1 7 4 5 10 6 3

D = 1 2 3 4 5 6 7 8 9 10

It performs recombination under the constraint that each city name come from one parent or the other

C' = 9 _ _ 1 _ 4 _ _ 6 _

C' = 9 2 3 1 5 4 7 8 6 10

D' = 1 8 2 4 7 6 5 10 9 3

Reordering Operators

Uniform Order-based crossover

A = 1 2 3 4 5 6 7 8

B = 8 6 4 2 7 5 3 1

0 1 1 0 1 1 0 0 (Binary Template)

A'= _ 2 3 _ 5 6 _ _

B'= 8 _ _ 2 _ _ 3 1

A'= 8 2 3 4 5 6 7 1

B'= 8 4 5 2 6 7 3 1

It combines the relative orderings of nodes on the two parent chromosomes in the two children

An order-based mutation operator

Mutation on a single gene of an order-based chromosome cannot be operated

Swapping of the values of two genes

Scramble sublist mutation

Example

Parent: 1 2 3 | 4 5 6 7 8 | 9

Child: 1 2 3 | 6 4 8 7 5 | 9

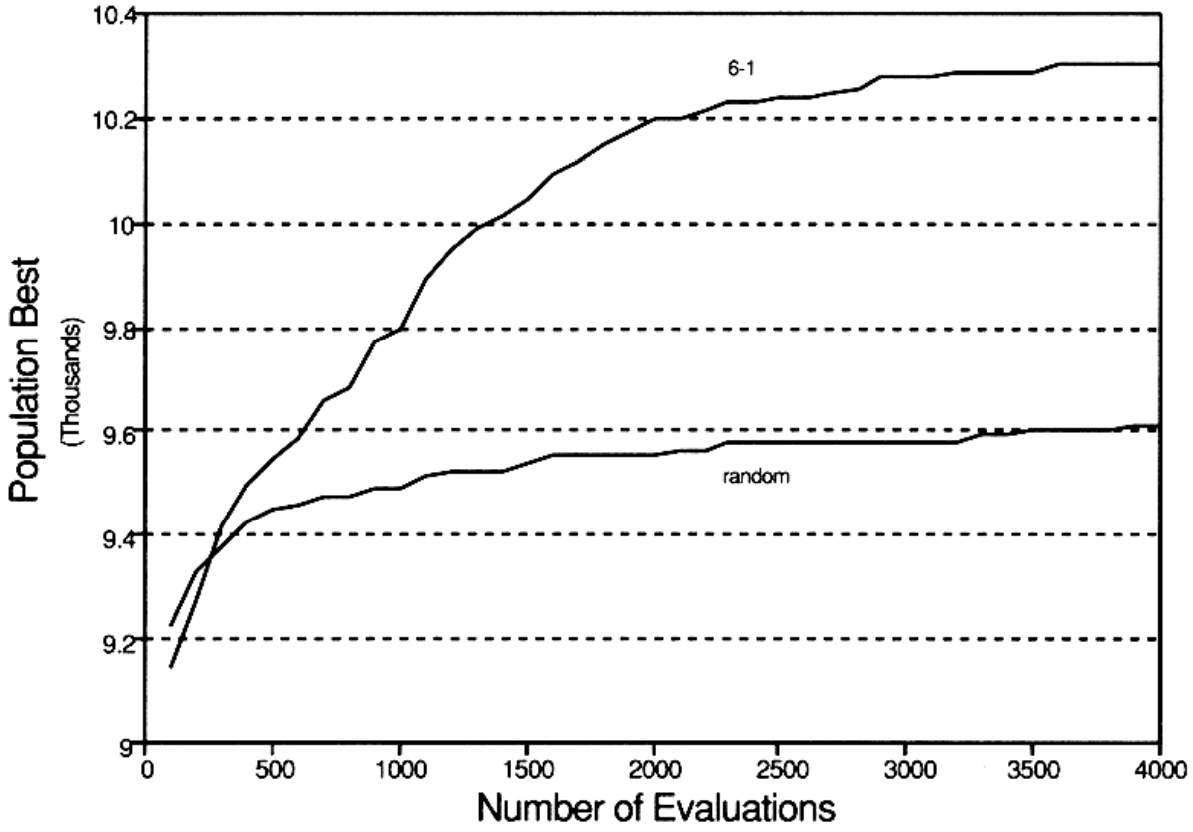

Figure 6.8: Performance curves for GA 6-1 and random generation on a 3-color graph coloring problem. The greedy algorithm scores 9,590.