Chapter 69

New Genetic Operator (Jump Crossover) for the Traveling Salesman Problem

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ABSTRACT

Inspired by nature, genetic algorithms (GA) are among the greatest meta-heuristics optimization methods that have proved their effectiveness to conventional NP-hard problems, especially the traveling salesman problem (TSP) which is one of the most studied supply chain management problems. This paper proposes a new crossover operator called Jump Crossover (JMPX) for solving the travelling salesmen problem using a genetic algorithm (GA) for near-optimal solutions, to conclude on its efficiency compared to solutions quality given by other conventional operators to the same problem, namely, Partially matched crossover (PMX), Edge recombination Crossover (ERX) and r-opt heuristic with consideration of computational overload. The authors adopt a low mutation rate to isolate the search space exploration ability of each crossover. The experimental results show that in most cases JMPX can remarkably improve the solution quality of the GA compared to the two existing classic crossover approaches and the r-opt heuristic.

1. INTRODUCTION

NP-hard problems generally require exponential time depending on the problem size to find exact optimal solutions. This is why many meta heuristics are used to obtain approximate solutions to problems of such difficulty.

Genetic algorithms are stochastic search methods which mimic the natural biological evolution. They are widely used in NP-hard problems optimization.

Genetic algorithms were developed by John Holland of the University of Michigan in the early 1970s (Holland, 1975) and since then, the GAs continue to prove theoretically and empirically their efficiency and robustness to provide good solutions in complexes areas (David Edward Goldberg, 1989).

GA operates on a population (group of individuals) of possible solutions applying the principle of survival of the fittest, to generate new and improved estimates. In every generation, a new set of approximate solutions is created by the process of selecting individuals according to their fitness (objective) and the use of genetic operators inspired by natural genetics. This approach guarantees the evolution towards better populations (Eiben, Hinterding, & Michalewicz, 1999).

The TSP is one of the most famous combinatorial optimization problems (NP-hard for large size), it was treated by a large number of meta heuristic methods and particularly genetic algorithms (Khan, Khan, Inayatullah, & Nizami, 2009; Potvin, 1996).

Researchers have proposed several versions of genetic operators for this kind of ordered problems such as order based crossover (OBX) and uniform order based crossover (UOBX) (L. D. Davis, 1991 chapitre 1 pages 1–101), partially mapped crossover (PMX) (David E. Goldberg & Lingle, 1985) and many others that we cite afterwards.

Here, we propose a new crossover Jump crossover (JMPX) then we compare it with some pretty powerful and classic crossover.

This paper is organized into 4 sections. The first deals with some basic concepts of genetic algorithms and a brief description of the operators of the benchmark. In the second section, we describe the proposed crossover operator. The third section presents the results and discussions in comparison with the benchmark, while the fourth section discusses the conclusions reached.

2. GENETIC ALGORITHMS FOR THE TRAVELING SALESMAN PROBLEM

2.1. Traveling Salesman Problem

The TSP is a classic combinatorial optimization problem, simple in its formulation but very difficult to solve. This problem is known to be NP-hard, in other words it cannot be solved exactly in polynomial time. Many exact and heuristic algorithms have been developed in the field of Operations Research (OR) to solve it. The problem is to find the shortest possible tour through a set of n vertices in such a way that each vertex is visited once and only once.

This problem can be divided into two categories depending on the form of the costs matrix: symmetric and asymmetric. If the equality $C(i, j) = C(j, i)$ is satisfied, the TSP is symmetric, otherwise it is called an asymmetric TSP, i and j being any vertex. In a symmetric TSP of n cities, there are (n-1)!/2 possible solutions and their inverses cyclic permutations with the same total cost. The purpose is then to find a Hamiltonian cycle with minimum total cost (Cicirello & Smith, 2000).

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