A Compressed Annealing Approach to the Traveling Salesman Problem with Time Windows

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Abstract
This paper describes a variant of simulated annealing incorporating a variable penalty method to solve the traveling salesman problem with time windows (TSPTW). Augmenting temperature from traditional simulated annealing with the concept of pressure (analogous to the value of the penalty multiplier), compressed annealing integrates penalty methods with heuristic search to address the TSPTW. Compressed annealing compares favorably with benchmark results in the literature, obtaining best-known results in numerous instances.

Keywords: simulated annealing, penalty methods, traveling salesman problem, time windows.

1 Introduction

As defined by the Council of Logistics Management, logistics is “the process of planning, implementing, and controlling the efficient, effective flow and storage of goods, services, and related information from point of origin to point of consumption for the purpose of conforming to customer requirements.” With the production trends of “lean manufacturing” and “just-in-time” operations, an inflated premium is placed on the freight industry to provide timely, efficient service. Potential savings in the form of decreased transportation costs, reduced inventory storage costs, and elimination of penalties due to untimely pick-ups or deliveries may result from improved routing assignments.

In general, time windows play a prominent role in routing problems for business organizations that deal with time-sensitive pick-ups and deliveries. As a gateway problem to more complex vehicle routing issues, we consider the traveling salesman problem with time windows (TSPTW). The TSPTW consists of finding a minimum-cost tour, starting from and returning to the same unique depot, that visits a set of customers exactly once, each of whom must be visited within a specific time window. Practical applications of the TSPTW abound in the industrial and service sectors: bank and postal deliveries, busing logistics, manufacture-and-delivery systems, and automated guided vehicle systems. In addition, the TSPTW is mathematically equivalent to time-sensitive production scheduling problems that are prevalent in manufacturing.

Solution approaches for the TSPTW range from exact mathematical programming techniques to various heuristic approaches. Exact approaches to the TSPTW have focused on dynamic programming techniques. Christofides et al. (1981) and Baker (1983) present branch-and-bound algorithms that solve problems with up to 50 vertices, but require “moderately tight” time windows and/or little overlap between them. Langevin