Abstract: This paper proposes a modified approach of sweeping to solve Capacitated Vehicle Routing Problem (CVRP). CVRP is a combinatorial optimization problem that has an additional constraint to the classic Vehicle Routing Problem (VRP) of limited capacity of the trucks. A set of trucks deliver goods to a given set of customers in which the total travelled distance of the trucks is minimized while the customers demand is fulfilled, and the truck capacity is not exceeded. Even though the problem itself may be complex to solve directly, it can be split into several Traveling Salesman Problems (TSP) using an approach referred to as sweeping, which segments the delivery zones in angular sectors, each corresponding to the delivery capacity of a vehicle. In this paper, a new form of sweeping that allocates vehicles to both angular and radial clusters of locations is proposed to improve solutions to problem instances with location clusters across the radial dimensions in terms of the total distance travelled. The experimental results indicate that the proposed approach reduces traveling distance by 2-4% for instances with clusters on radial positions, while indicating that it increases traveling distance in cases with no clusters present.

Keywords: Capacitated Vehicle Routing Problem, Vehicle Routing Problem, Sweeping, Travelling Salesman Problem

1. Introduction

The rise in online ordering and the high transportation costs associated with the delivery of these orders urges the need of route optimization for vehicles delivering these goods. An optimized route for the delivery can decrease the distance travelled by the vehicles significantly and therefore decrease the cost associated with the delivery. The problem of finding an optimal route for a set of vehicles visiting a set of locations is referred to as the Vehicle Routing Problem (VRP). A more general form of this problem is the Capacitated Vehicle Routing Problem (CVRP) where vehicles have limited capacities, locations have demands, and solution routes must guarantee the satisfaction of all demands while not exceeding vehicle capacities (Dantzig and Ramser, 1959). Applications to CVRP include the delivery of goods to customers using courier services such as FedEx home delivery service and UPS delivery.

Several approaches have been proposed over the years to solve CVRP. Most of these approaches are heuristic approaches since exact algorithms such as branch and bound and branch and cut require non-polynomial time to solve large size problems. However, heuristic approach does not explore the entire search space but rather tries to find an optimal solution based on the available information of the problem.

One of the main difficulties with CVRP is performing routing subject to vehicle capacity constraints. These two concerns can be separated using a two-phase heuristic approach known as the Sweeping Algorithm (SA) (Suthikarnnarunai, 2008) proposed by Gillett and Miller (1974). This algorithm is constructed to generate routes for vehicles in which a solution to Travelling Salesman Problem (TSP) takes place in the second stage. In this approach, an initial location is chosen (conventionally the depot) and locations are sorted according to their angular position to this location. A “sweep” is then started from angle 0 in the clockwise direction, including as many locations as possible until the capacity of a certain vehicle is exhausted. This vehicle is then assigned the just swept sector of locations. The process is then repeated, this time starting from the angular position where the previous iteration ended, to determine the delivery sector for the next vehicle and so on. SA is a widely used method for clustering that basically clusters the nodes solely by polar angle, this can form a problem if the nodes are widely separated but have less angular distance as they can be assigned in the same cluster, and this reduces the optimality of the resulting cluster.

In this paper, CVRP problem instances with clusters on radial positions are considered. Such instances tend to be common in practice. For example, many cities around the world contain residential blocks separated by rings of roads, including London (3 ring roads), Houston in Texas (3 ring roads) and Beijing (6 ring roads). In such cities, allocating vehicles per rings will be more optimal as it will avoid repetitive crossing of ring roads, which may increase distance significantly. SA does not take this into account. A modification to SA is proposed that can improve the handling of problem instances with clusters on