COMBINING MONTE CARLO SIMULATION WITH EXACT METHOD TO SOLVE A RANDOM PROBLEM OF COLLECT INFECTIOUS HEALTHCARE WASTE: THE CASE OF TUNISIA

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Abstract

Improper waste management can cause environmental pollution, unpleasant odours, and growth of insects, rodents and worms; it may lead to transmission of diseases like typhoid, cholera, and hepatitis through injuries from sharps contaminated with human blood (Abdulla *et al.,* 2008). This study discusses the off-site transport problem of infectious healthcare waste from the 16 hospitals in the governorate of Sfax (Tunisia) to a planned steam sterilization disposal centre. Experimental results are reported for the proposed real-life case study from combining Monte-Carlo simulation and exact method. The robust proposed solution method can be considered to be important for a licensed company or for the Sfax municipality for healthcare-wastes transportation system and for CVRP practitioners.

Key words: capacitated vehicle routing, infectious healthcare waste, exact optimization, Monte-Carlo simulation.

1. Introduction

The waste management of health care activities (WHA) is one of the most important environmental problems in the world and especially in Tunisia because of the potential environmental hazards and risks to public health. The amount of medical waste generated by Tunisian health facilities has been increased rapidly and an appropriate management system is indeed needed to eliminate environmental and health hazards. The collection of infectious health care waste is a necessary and important service that involves large expenses.

2. Problem Description

Based on Stockholm Convention which aims to improve sanitary conditions in Tunisia by reducing the risk of contamination and diseases closely related to the handling of WHA, we have treated this problem as a qualified vehicle routing problem which is characterized by a random parameter (demand) (CVRP). Hospital waste is removed using a truck assembly for treatment. A group of companies deals with this type of treatment. A route planning model is proposed to minimize the total distance of travel, which aims to reduce transportation costs and emissions from vehicles and a simulation method is used which is based on the random draw of a large number for each demand in order to find the probability of occurrence of each of the results.

In this work, we are interested in dealing with a problem of infectious waste management. The regular management of the collection of this waste is one of the main problems to be addressed for any organization that produces hazardous waste in order to avoid damage to the environment and human health.

The objective is to assist the decision of waste collection companies by providing the best solution to minimize the total distance traveled by satisfying the demand of each establishment while respecting the capacity constraint of each vehicle that starts and ends with the same deposit.

Recently, several researchers are interested in solving the vehicle routing problem. Some recent works include: Oliviera and Delgado (2015) propose an algorithm based on Monte Carlo simulation and clarke and right savings heuristic. This study compares the result with existing benchmarks in the literatue. Alemany et al. (2016) integrate Monte-Carlo simulation within a heuristic algorithm in order to deal with a rich and real life vehicle routing problem.

Given this situation, it is necessary to minimize the total travel distance of collection trucks. Minimizing travel distances will in turn reduce travel costs and also reduce emissions to the environment.

3. Proposed approach

In this work, and in a first part, we solved this problem with an exact method based on the basic model initially proposed by Kara et al., (2004). Solving this problem with the ILOG CPLEX software could provide solutions in a reasonable amount of time. In a second part,

and to give the best solution, we base on the Monte-Carlo simulation method which has for essence the use of repeated experiments to evaluate a quantity, to solve a deterministic system and centered on a calculation using randomly.

4. Conclusion

This paper presents an optimization approach which integrates Monte Carlo simulation (MCS) with an exact algorithm in order to deal with a real-life vehicle routing problem. A set of customers' orders must be delivered from one depot and using homogeneous vehicles. The Monte-Carlo component, which is based on the use of a skewed probability distribution, allows transforming a deterministic model into a probabilistic procedure and demonstrated results comparable with the existent in this real case.

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