Convex Optimization
for
Single-vehicle cyclic Inventory Routing problem

Optimization Algorithms and Techniques (CS-357)
Project Proposal

- under the Humble Guidance of Dr. Kapil Ahuja Sir and Saurav Kumar Sir

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INTRODUCTION

Traditionally, each stage in a manufacturing supply chain optimizes its own processes. Processes such as purchasing, inventory control, production, sales, and distribution are managed differently in every stage of the supply chain.

Due to ever-increasing competition and reduced profit margins, it was decided to synchronize all the above activities to **minimize the costs involved in all these processes and maximize the returns/profits.**

One of the policies that support the synchronization of different activities is Vendor Managed Inventory (VMI). In a VMI system, the supplier is responsible for managing the inventory of his customers. The supplier decides when and which quantity to deliver to his customers. By combining orders to different customers the supplier can make significant savings in distribution costs.

The combined inventory management and routing problem, the supplier is confronted with in VMI, is called the Inventory Routing Problem (IRP). In this project, we consider the Single-Vehicle Cyclic Inventory Routing Problem (SV-CIRP).

BRIEF OVERVIEW

Generally, the IRP is concerned with the distribution of products from one or more facilities to one or more customers over a given planning horizon(time period allotted for the execution of plans) . Here, we consider the Single-Vehicle Cyclic Inventory Routing Problem (SV-CIRP) which is a more generalized form of IRP which is a one-to-many IRP with an infinite planning horizon.

FORMULATION

Our overall goal is to minimize the transportation, delivery, and holding costs while maximizing the collected rewards from the constraints subject to different constraints as applicable. We will present a detailed formulation of the problem in upcoming deliverables. Here, we present a brief formulation.

$$\min \psi + \sum_{i \in S^+} \sum_{j \in S^+} \left(\left(\delta \nu t_{ij} + \phi_j \right) \frac{1}{T} + \frac{1}{2} \eta_j d_j T \right) x_{ij} - \sum_{j \in S^+} \lambda_j \sum_{i \in S^+} x_{ij}$$

<u>Sets of the model:</u>

- S Set of customers
- S+ Set of actors, customers and supplier

Parameters of the model:

- $\mathbf{T_{ij}}$ Travel time from customer i to customer j (time)
- $\mathbf{d_j}$ Demand rate at customer j (quantity/time)
- Ψ Fixed operating cost of vehicle (price/time)
- δ Travel cost of the vehicle (price/distance)
- $\mathbf{v}$ Vehicle speed (distance/time)
- φ_j Fixed ordering and delivery cost at customer j (price)
- η_j Holding cost at customer j (price/(time quantity))
- Λ_j Reward if customer j is selected for replenishment (price/time)
- K Capacity of the vehicle (quantity)
- $\mathbf{Q_{jmax}}$ The largest possible quantity that can be delivered to customer j (quantity).

GOALS

Our goals for this project will be :-

1. **Taking up a real-world problem(In our case, SV-CIRP) and understanding its intricacies and applications.**
2. **Formulating it as a convex optimization problem so that it can be solved using known methods.**
3. **Learning the various algorithms applicable to this problem to optimize the gains.**
4. **Implementing the algorithms and analysing the results.**

MOTIVATION

According to a study by Digital Commerce 360, reported on Inc. The top 500 companies generated a revenue grossing over 849.5 billion USD in terms of online sales reported in 2020, and the figures (the gains as well as the overheads involved) are growing exponentially.

E-Commerce firms have to face the problem of inventory management and distribution amongst their clients. The study of SV-CIRP and the results obtained by forming a well-formulated mathematical model can maximize their profits.

Thus, we felt that the problem under consideration has a huge impact in this industry field and as time passes, its study becomes more relevant.

Hence we decided to take up the problem of the Single-Vehicle Cyclic Inventory Routing Problem (SV-CIRP).

REFERENCES

- *Andersson H, Hoff A, Christiansen M, Hasle G, Løkketangen A. Industrial aspects and literature survey: combined inventory management and routing. Comput Oper Res 2010;37(9):1515–36*

- *A convex optimization approach for solving the single-vehicle cyclic inventory routing problem*