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Supply Chain and Differentia Evaluation

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Contents:

Abstract:

Genetic algorithms are among the oldest ways to solve complex life problems that are difficult to solve by ordinary methods.

This article will include a type of problem that genetic algorithms can solve, and this type is supply chain.

The supply chain consists of many complex processes that are equally important to maintaining a successful supply chain.

And this article will contain the studies of four different researches, and they are:

1. **Genetic algorithms in supply chain management: A critical analysis of the literature.**
2. **A genetic algorithm approach for solving a closed loop supply chain model: A case of battery recycling.**
3. **Optimization of Supply Chain Network using Genetic Algorithms based on Bill of materials.**
4. **Mathematical Modeling of a Supply Chain with Uncertain Parameters.**

Genetic algorithms in supply chain management: A critical analysis of the literature

Introduction:

The world has always viewed the process of maintaining the supply chain as a very important matter, because the overall economy of any country depends on the supply chain operations, so it must be well managed.

And with the increase in competition between countries, the supply chain has become more complex, so researchers in this field focus on technologies that may be effective and powerful with the supply chain.

And in this article [1], the GA application will be discussed and reviewed, which is one of the most widely used applications in the field of distribution chain, due

to the fact that GA has a great ability to develop solutions, deal with ambiguity, and implement improvement and competence to tolerate imprecision, uncertainty, and partial truth to attain tractability and robustness on simulating human decisionmaking behavior with low cost.

Moreover, GA has been applied quite successfully to a wide range of problems occurring in diverse SCM domains, for example, forecasting , job-shop scheduling , economic lot-size scheduling , economic lot-size model, vendor-managed replenishment system .

Genetic algorithms:

GA is an evolutionary algorithm first proposed by John Holland and his colleagues in 1975. Based on Darwin's theory of survival of the fittest, it is one of the most popular search techniques used for solving optimization problems.

(1) Build initial population of randomly generated solutions.

(2) Evaluation of the fitness function of individual solutions in the population.

(3) Generate new population by repetition of subsequent phases as follows:

- **Selection: Pick a pair of parent solutions from a population corresponding to their fitness. The one having a superior fitness value is more likely to be selected.**
- **Crossover: Perform crossover with the help of a predefined crossover probability to produce new child solution.**
- **Mutation: Perform mutation by means of a prede-fined mutation probability.**

(4) Adopt newly build population for an additional run of the algorithm.

(5) Check whether the stopping criterion has been reached. If yes, then terminate; otherwise go to step 2.

Several variants of GA are available in literature, including binary and real encoded; unconstrained and constrained; and single objective and multi objective, depending on the type of problem being dealt with, the suitable variant may be applied.

Supply Chain Management:

It is a set of methods to form and manage the relations between the supplier and the importer to provide high-quality value to customers at the lowest price. Its work is to manufacture and allocate the right quantity at the right time and in the right place to combine cost reduction and customer satisfaction.

Introduction:

As a result of global competitive pressure, companies today are forced to offer higher quality products at lower prices in order to survive in the market.

The competitiveness of a company is mainly determined by supply chain efficiency.

Supply chain network:

In summary, globalization has transformed business dynamics, requiring companies to collaborate with partners and adopt a customer-oriented approach.

This has led to the emergence of supply chains, where multiple organizations work together to create and deliver products to customers.

The supply chain is a collaboration of multiple units working together to procure raw materials, transform them, produce end products, and distribute them to customers.

It involves coordination and integration of organizations with individual goals to achieve a common objective.

The performance of the entire supply chain relies on the behavior of its individual members.

While optimizing the performance of each member is important, it is crucial to consider the supply chain as a whole to enhance its overall performance.

To maximize profit, it is crucial to identify the optimal structure or design of the supply chain network.

The selection of partners within the supply chain network forms the basis for cooperation among members at various levels: upstream, midstream, and downstream.

When designing a supply chain, several economic decisions need to be made, including:

1. **Determining the number, size, and locations of supply chain nodes.**
2. **Deciding on the number and locations of production facilities.**
3. **Allocating the appropriate capacity at each location.**
4. **Assigning market regions to one or more locations based on demand.**
5. **Selecting suppliers for components and materials.**

These decisions play a vital role in shaping the efficiency and effectiveness of the supply chain network.

By carefully considering these factors, businesses can optimize their supply chain operations and enhance profitability.

GENETIC ALGORITHMS IN SUPPLYCHAIN NETWORK OPTIMIZATION:

4.1 General Approach:

The conversion of a phenotype (decoded variable) into a genotype (coded variable) is important for efficient optimization. The coding method used influences fitness calculation and quality in the solution space.

There are various coding methods, including binary coding, real number coding, integer/literal permutation coding, and general coding. The choice of coding depends on the problem's properties. In supply chain network problems, chromosome representation involves multiple parts that describe the assignment between participants. The number of genes in a chromosome depends on the depth of the value chain and the number of customers involved.

A genetic algorithm approach for solving a closed loop supply chain model: A case of battery recycling.

Introduction:

Forward supply chain:

A forward supply chain is a network that encompasses facilities and distribution options to carry out procurement, transformation of materials, and distribution of finished products to customers.

Supply chains exist in various industries and organizations, with varying degrees of complexity.

Optimizing supply chain networks in real-world business environments is challenging due to uncertainties in supply and demand, conflicting objectives, and tradeoffs across different elements of the chain.

The supply chain leader, typically the manufacturer, faces these difficulties in managing the chain effectively.

Reverse supply chain:

A reverse supply chain focuses on the reverse flow of materials from customers back to suppliers or for alternate disposition.

Its objectives are to maximize value from returned items or minimize the overall cost of reverse logistics.

Reverse logistics, as defined by Rogers and Tibben-Lembke, involves planning, implementing, and controlling the efficient and cost-effective flow of raw materials, in-process inventory, finished goods, and related information from the point of consumption back to the point of origin for the purpose of recapturing value or proper disposal.

Reverse distribution can occur through the original forward channel, a separate reverse channel, or a combination of both channels.

Closed loop supply chain:

In today's world, the closed-loop supply chain (CLSC) has gained significant importance due to increasing environmental concerns and strict regulations regarding product wastage throughout its lifecycle.

A CLSC includes both the forward supply chain and the reverse supply chain.

The forward supply chain involves the movement of goods from suppliers to customers, while the reverse supply chain focuses on the return and potential recycling or reuse of used or unsold products.

Integrating the reverse supply chain into the forward supply chain has been found to reduce overall costs and ensure compliance with governmental and environmental regulations.

Therefore, it is necessary to model and analyze closed-loop supply chains as a unified system rather than separate the forward and reverse supply chains.

Battery recycling:

Recycling involves processing products to recover materials for reuse without preserving the original product structures.

Examples of recycling include plastic, paper, glass, sand, electronic waste, carpet, and battery recycling.

Environmental protection and conservation of natural resources have become crucial at national and international levels.

The management of hazardous waste is a complex issue, addressing environmental deterioration prevention, minimizing waste generation, and recovering valuable materials.

The study focuses on recycling lead-acid batteries, which are considered hazardous due to their corrosivity, reactivity, or toxicity.

Lead-acid batteries have been widely used in automotive applications for starting, lighting, and ignition services, as well as powering vehicles like automobiles, forklifts, and submarines.

The main components of a lead-acid battery include:

i. **active mass:**
    1. **anode (PbO_2)**
    2. **cathode (Pb)**
ii. **metallic grids and connections**
iii. **electrolyte (H_2SO_4 solution)**
iv. **polypropylene casing**
v. **other components such as wood, paper, and PVC.**

In recent years, battery recycling has received increasing attention from researchers and practitioners due to the rise in vehicles and the presence of heavy metals like lead, mercury, and cadmium.

Lead-acid batteries, with their high lead content (97%), are among the most highly recycled consumer products, surpassing the recycling rates of aluminum cans, newspapers, glass bottles, and tires.

Lead can be recovered through material separation or by processing the entire battery through heat treatment in a specialized furnace.

The closed-loop life cycle of lead-acid batteries is environmentally beneficial, with new batteries typically containing 60-80% recycled lead and plastic.

Spent batteries are sent to permitted recyclers where lead and plastic are reclaimed and used in the production of new batteries, enabling a continuous recycling cycle.

The successful disposal of lead-acid batteries offers environmental and cost advantages.

Problem description:

This study focuses on a battery manufacturing company located in southern India and aims to assess the feasibility of reclaiming lead from automotive batteries.

The forward supply chain involves procuring raw materials such as lead, plastic, and sulphuric acid from various suppliers for battery production.

These batteries are used in two-wheelers, four-wheelers, and other industrial applications.

After production, the batteries are distributed through a network of distributors, wholesalers, retailers, and ultimately reach the customers.

Once the batteries reach the end of their life, they are collected at automobile service stations and transported to a centralized return center.

At the return center, the batteries are inspected for quality and sorted for potential repair or recycling.

Useless batteries are disposed of, while reusable batteries are sent to disassembly/recycling plants.

In the recycling process, batteries are crushed and separated into different components, with the remaining components (plastic, acid, etc.) sold to third parties for other applications.

The recycled lead is then transported back to the battery manufacturing plants, where it is used alongside virgin lead for new battery production.

The problem addressed in this study is to develop a multi-echelon, multi-period, and multi-product closed-loop supply chain model. The objective is to minimize the total supply chain cost, including procurement, production, distribution, inventory, collection, disposal, disassembly, and recycling costs. To solve this problem, a genetic algorithm is used.

Note : This Problem Solved in Research paper.

Mathematical Modeling of a Supply Chain with Uncertain Parameters

INTRODUCTION:

Supply chain models play a crucial role in maximizing service levels, minimizing transit times, and reducing costs in supply chain management.

The mathematical formulation of these models is an important aspect that aims to achieve minimum costs.

Supply chain management involves addressing the conflicting interests of participants in the supply chain, such as purchasing, manufacturing, and transportation.

Transportation, being a key component, significantly impacts the profitability of companies.

It is essential to have cost-effective transportation to ensure efficient supply chain management.

Optimization of supply chains requires appropriate scheduling, planning, and control policies, considering constraints and uncertainties.

Various methodologies, including fuzzy base rules, possibility theory, interval analysis, and robust optimization, are used to model uncertainties.

Robust optimization has gained significant academic interest due to advancements in computer science and simulation techniques.

Robust Optimization Procedure:

In this section, in order to clarify the model, we provide a brief introduction to robust optimization procedure introduced by Bertsimas and Sim (2004). Consider the following uncertain linear model:

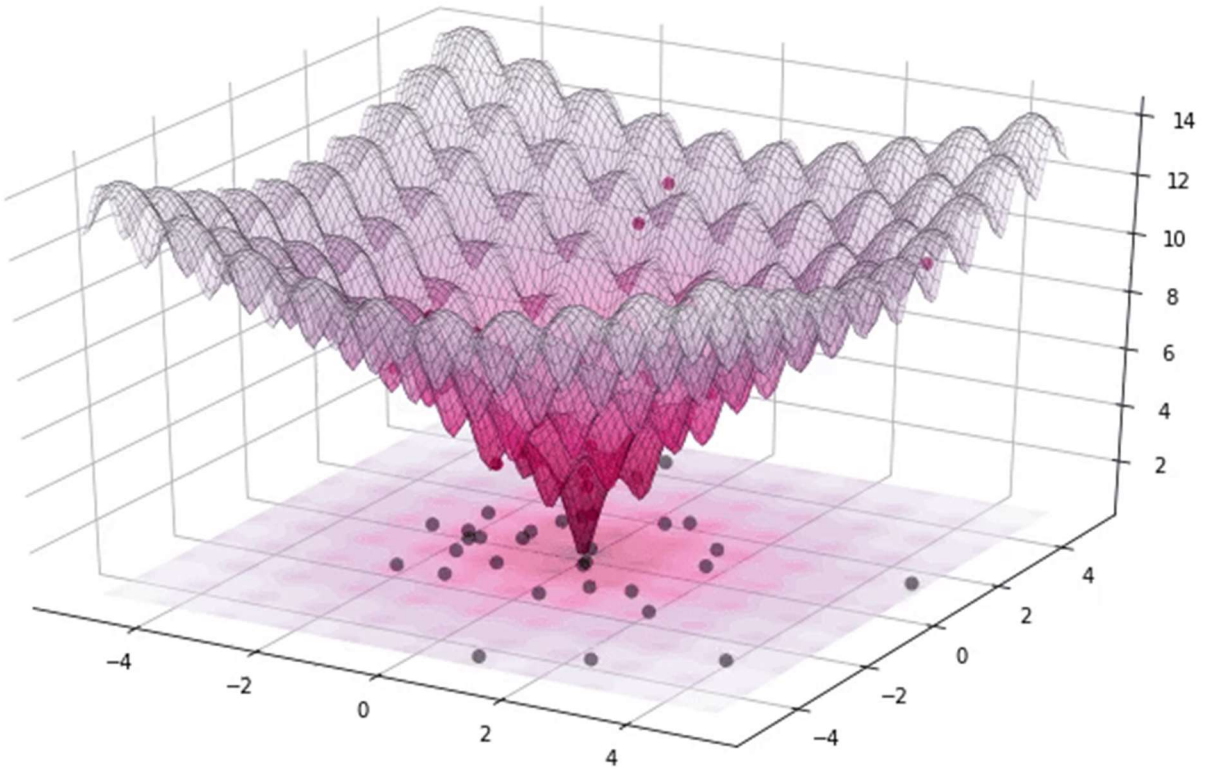
$$
\begin{aligned}
& Min \sum_{i,j} c_{ij} x_j \\
& S.t.: \ \sum_i \tilde{a}_{ij} x_j \geq b_i \quad \forall i \\
& x_j \geq 0 \quad \forall j
\end{aligned}
$$

- **Note: This is Example of (OBFun),(Const.) in research paper have a lot of examples and solve the problem.**

Summary of Supply Chain and Differentia Evaluation:

In summary, the relationship between supply chain and differentiation evaluation can be understood as follows:

Supply chain management plays a crucial role in supporting a company's differentiation strategy by creating value through efficient operations, timely delivery, and excellent customer service.



An effective supply chain enables companies to introduce innovative products, customize offerings, and respond quickly to market demands, thereby enhancing their differentiation.

Maintaining high product quality and reliability through a well-managed supply chain contributes to differentiation by building a reputation for excellence.

Speed to market is critical for differentiation, and an optimized supply chain helps companies reduce lead times and accelerate product launches.

Collaboration and partnerships within the supply chain provide access to unique resources and expertise that can support differentiation efforts.

In conclusion, a well-structured and efficiently managed supply chain is essential for companies to achieve and sustain differentiation in the marketplace by enabling value creation, innovation, quality, speed, and collaboration.

About The Code Implementation

INTRODUCTION:

The supply chain of the is one of the important process in any business and most the business be big most the process of the supply chain be more complex .

So the development team in any organization have a goal to minimize the cost of the supply chain process , and this team will make a model for the process and then need to solve this model with an algorithm .

Most be careful to choose the algorithm that will be suitable for solve the model of the supply chain , so we here in this study choose the “Differential Evolution” algorithm , but we don’t choose this algorithm by luck but there are some advantages of the “differential evolution" algorithm :

1. Scalability: Differential evolution is a scalable algorithm that can be used to solve large and complex supply chain models.
2. Efficiency: Differential evolution is an efficient algorithm that can find good solutions to supply chain models quickly.
3. Robustness: Differential evolution is a robust algorithm that can handle noise and uncertainty in supply chain models.
4. Flexibility: Differential evolution is flexible algorithm that can be used to solve a wide variety of supply chain models.

Description of the differential evolution algorithm :

Differential evolution is the one of the simple algorithms that used to solve the optimization models .

The differential evolution algorithm consist of 4 steps that repeated until reach to the stopping criteria :-

1. First : Initialization
2. Second : Mutation
3. Third : Crossover
4. Fourth : Selection

- Tricky step that differential evolution use to get optimum solution is :

Make difference in the mutation to decrease the search space and reach to optimum solution .

Lets to describe each process in the algorithm :

1. **Initialization** :
   in this function we make randomly generate the population .

2. **Mutation :**
   In the mutation we choose the target_vector , then choose 3 random vectors from the population that there are no equality between them and these 3 vector no one of them equal to the target_vector.

   Then make the difference operation (the tricky step that algorithm made to reach to solution)

   This function generate a vector named “mutated vector “

3. **Crossover :**
   In the crossover function we take 2 vectors (target_vector , mutated vector) , and then make loop .
   In the loop we generate random number and then check if the random number bigger than Crossover probability (take value from the targt_vector) , or if the random number less than the Crossover probability (take value from the mutated_vector) .

4. Selection :
   In the selection , we choose the new_child based on the best fitness between the target_vector and the trial_vector.

Some initial values use before starting the algorithm :

- crossover probability = 0.9
- weighted f = 0.8
- NP = 10 * D” .

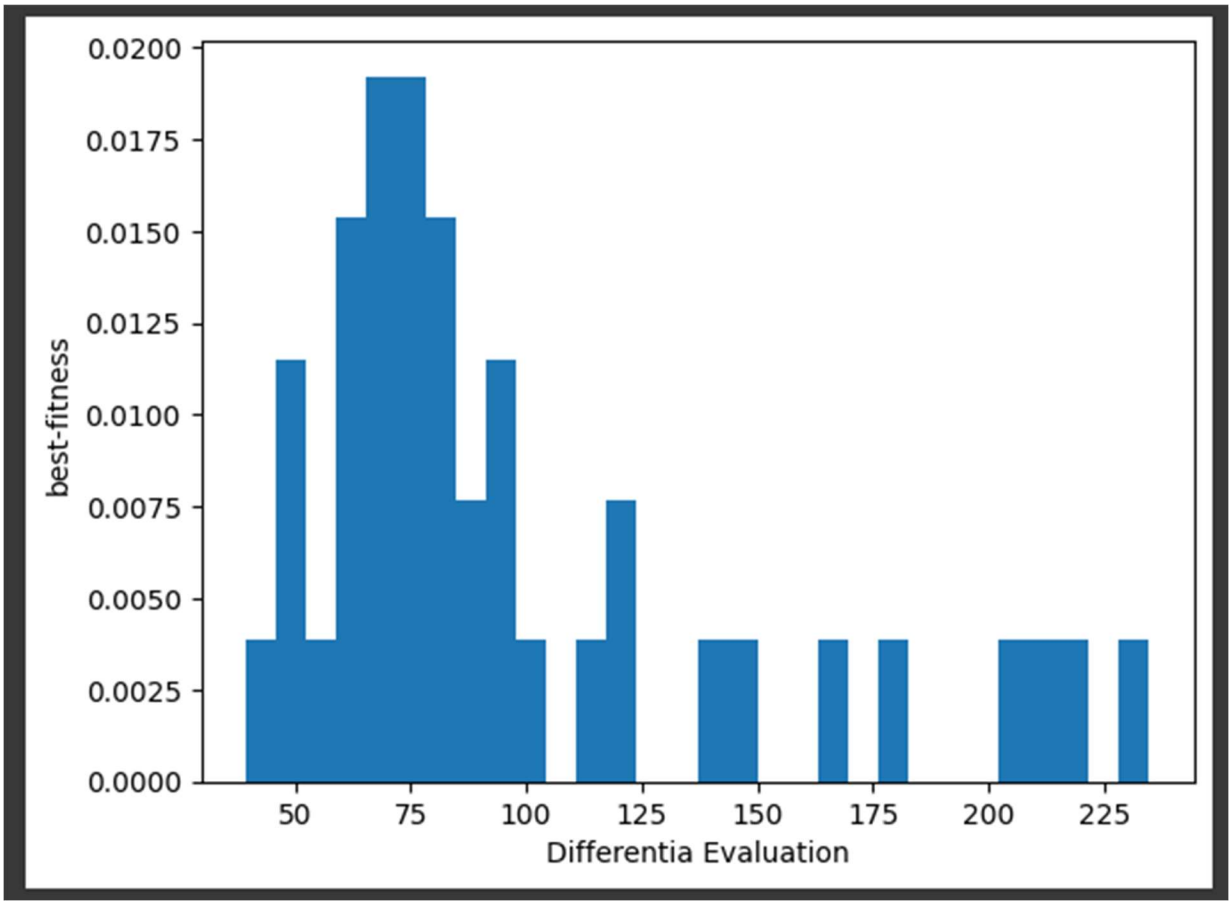
Example of OutPut:

```
enter the number of iterations : 2
1.32        17.98       2.04        5.32        11.08       2.64
19.59       6.13        16.55       5.13        19.94       2.57
5.92        8.01        11.48       1.84        8.83        12.15
8.54        10.01       13.79       11.19       5.7         12.98
16.04       15.28       14.85       6.39        11.61       11.48
5.76        11.49       6.57        19.89       8.25        19.88
16.91       16.44       11.32       9.33        10.52       12.04
12.02       3.4         18.84       2.9         14.8        12.36
12.26       18.48       17.68       15.04       11.29       9.66
14.6        15.64       2.22        1.39        10.08       2.06



the new generation is :
1.3         7.1         2.0         5.3         11.1        20.2
69.9        69.9        69.9        69.9        69.9        69.9
70.9        8.0         11.5        1.8         8.8         67.4
62.2        62.2        62.2        62.2        62.2        62.2
18.4        15.3        14.8        6.4         12.7        11.5
5.8         11.5        28.8        42.4        8.2         19.9
76.6        76.6        76.6        76.6        76.6        76.6
64.3        64.3        64.3        64.3        64.3        64.3
12.3        18.5        17.7        87.6        11.3        87.3
14.6        15.6        2.2         1.4         41.5        45.8
```

The Plot of the Progress in optimization:



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